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LENIN

Russian atomic ice-breaker

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OUR COVER PICTURE

The Russian Nuclear-powered Ice-breaker *Lenin*. See p. 498.

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THE PROGRESS OF SCIENCE

FOOD FOR THOUGHT

No issue goes more deeply to the heart of man's efforts to master his environment than that of sustaining his food supplies.* In Britain this problem is perceived at two interrelated levels: first, the narrow but nationally urgent one, especially in times of conflict or crisis, of providing adequate and varied supplies of food for a country which, while far from self-sufficient, enjoys one of the highest living-standards in the world; and second, the global need to meet the food requirements of the rapidly expanding world population, a high proportion of whom are in any case under-nourished. As to the precise methods whereby Britain and the world can meet their objectives in the matter of food requirements, and the indispensable and increasing contribution science can make, it is readily conceded that the picture itself is a fast-changing one, and that the answers are not as simple as appears at first sight. But as to the importance and validity of our main objectives there can be little doubt, and it is desirable that the issues be understood as widely as possible, if human ingenuity is to find solutions.

In relation to the world's food problem, Britain's difficulties may sound parochial, and with the return of food surpluses in certain countries, the need—so apparent of recent years—to increase home agricultural production would now seem less pressing. Nevertheless, a continuing rise in output and the raising of the efficiency of British agriculture remains essential, for otherwise there would be both overdependence on potentially precarious foreign food supplies and the gradual impoverishment of home producers which could be nationally self-defeating. Examples abound of the scope for higher productivity in British agriculture, so necessary to counteract land-loss and to improve the industry's competitiveness; thanks to existing scientific techniques, figures can show remarkable differences in output between average and really good farms, while numerous examples can also be given in such fields as waste control, grassland improvement, and so forth, of further advances from scientific improvements as yet barely tapped. This potential, however, focuses attention on the personnel problem. The more intensive application of science to farming demands extensive strides forward in the scientific education of our farming community; nothing less will do.

Though the British public is sensitive about its food position, the critical nature of the world food outlook is one which demands a considerable effort of imagination. True, the Malthusian controversy is not new, but previous forecasts of population outstripping food resources have so far, thanks largely to scientific progress, come to naught. Nevertheless, though there are naturally wide differences of view even among demographers, there are special reasons why the present situation should be viewed with alarm. Not only is world population increasing at about 50 million people per annum, but it is generally accepted that this rate of increase is faster than any recently known. Projections of world population are being constantly revised upwards, and the lowest estimate of United Nations demographers is of an existing population of 2800 million people rising to 5000 million by A.D. 2000. While many people will reject the more gloomy forecasts, such as that attributed to Sir Charles Darwin, that if the present rate of advance were sustained for another 20,000 years, there would be standing room only in the world, it is far from certain that man's social organisation could adapt itself sufficiently rapidly to the challenge which such figures present.

Many roads will have to be searched for a solution. There is the paramount need for much greater world food production. The optimistic view that with the passing of the immediate post-war years, world agricultural production would rise faster than world population has been brought into question. The 1958 FAO report on "The State of Food and Agriculture" suggests that world *per capita* food production last year declined; moreover, the problem is aggravated by the fact that any comparative increase in *per capita* food production since pre-war has been largely in the more developed countries, while in the less developed areas there has been no perceptible improvement.

Whether the task of raising and distributing agricultural output is one that, given the right policy framework and co-operation, can be tackled by sovereign governments, or whether it is a task for world planning and action, there is no mistaking its urgency. Nor can there be any underestimating of the vital part that science can play at the many stages of its solution—better production techniques, more effective land utilisation, greater knowledge of nutritional principles and practice, to mention a few.

While a sustained and rapid rise in food production alone does not provide a solution to the problem, it does give an opportunity for its solution. Thus, though we do not fully understand all the pressures behind the present population upsurge, it seems fairly probable that a significant rise in living-standards will bring about lower birth-rates to offset the lower death-rates secured by medical science. But there is one *conditio sine qua non*—a scientific assessment of the problem by governments and their ability, in the face of social and religious barriers, to formulate a population policy, including limitation of population.

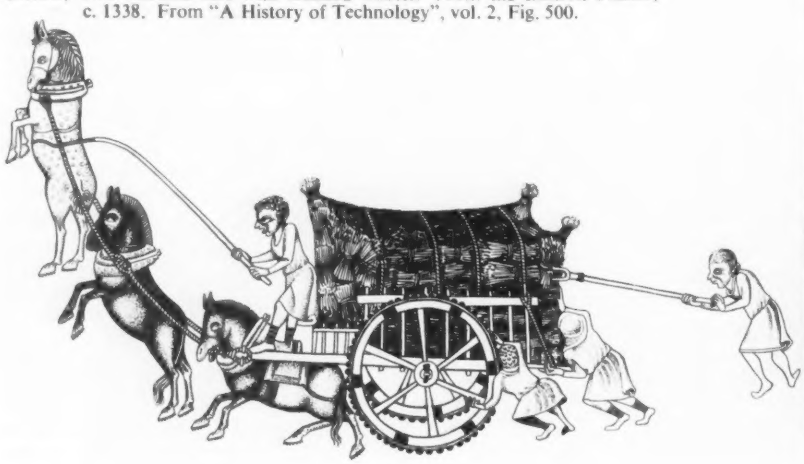
Certainly there are effective ways for society to assess and meet the world population challenge, and if past achievements are any guide, to overcome it. Nor should it be supposed that the resources of science are exhausted by conventional remedies. There are many exciting advances to be made; man has barely touched on the possibility of full utilisation of the earth's surface, the scope for chemical foods, the potential of the sea as a provider of vegetable *pabulum*. The increased exploitation of the sun's energy for the creation of foodstuffs must also be more fully explored; the dividends will doubtless be rich. Nor is it any longer realistic to discount space-travel in the human equation and to disregard the possibility that mankind may be destined to people other planets.

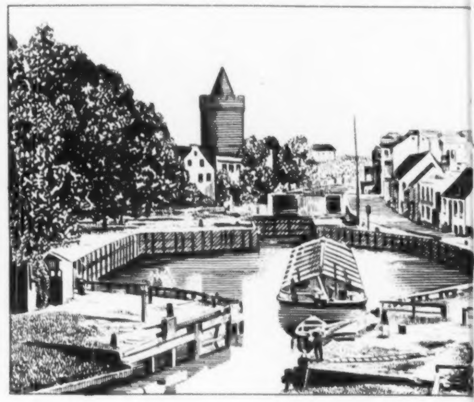
* See also page 522.

TRANSPORT THROUGH

(*Above*) Pack-asses among a group of tribute-carriers. From a tomb at Beni Hasan, Egypt. c. 1900 B.C. From "A History of Technology", vol. 1, Fig. 507.

(*Below*) Two-wheeled cart with studded wheels. From the Luttrell Psalter, c. 1338. From "A History of Technology", vol. 2, Fig. 500.





"A HISTORY OF TECHNOLOGY"

The publication last month of the fifth and final volume of "A History of Technology" completed a major publishing venture initiated by Imperial Chemical Industries some eight years ago. The Company's interest in the furtherance of technical education is well known, but in pursuing this policy it has always kept in sight the fact that scientific and technological studies need to be joined in some way with those of the humanities. It is generally accepted that one useful way of doing this is through related historical studies. The history of science has received a great deal of attention, but the history of technology—which in its widest sense means the history of how things are made—has been comparatively little studied. Accordingly the idea was conceived of a comprehensive study of the world's principal technologies, from the earliest times to the beginning of the present century. The present work represents the fulfilment of this idea, and the reception given to it fully justifies the Company's conviction that this would be a worth-while project.

Eminent reviewers have paid great tribute to the first four volumes of "A History of Technology" in DISCOVERY, they appear in DISCOVERY, 1955, vol. 16, p. 86; 1957, vol. 18, p. 532; 1958, vol. 19, p. 252; 1958, vol. 19, p. 390.

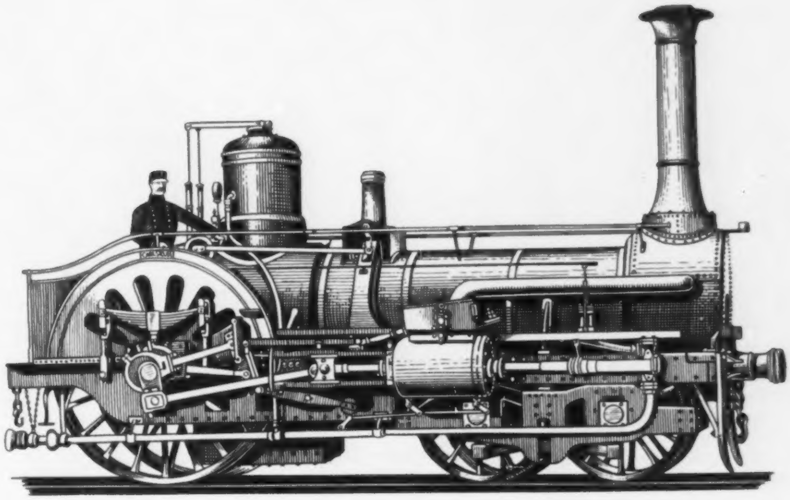
"A History of Technology" can fairly be described as a substantial work of scholarship, consisting as it does of five 800-page volumes. The 134 chapters, each written by an acknowledged expert on the subject, are liberally illustrated. Each finishes with a bibliography so that those who wish to read further can do so. There are some 2500 line drawings, the majority of them specially drawn for the book, and a further 200 pages of carefully selected halftone illustrations. The book has been kept as non-technical as possible, and it is designed to be read by those who have little acquaintance with either the history of science and technology or that of man. At the same time, it is authoritative enough to prove a useful auxiliary to the specialised studies of archaeologists, historians, and other scholars.

In making the work available, ICI established a most appropriate relationship with the Oxford University Press.

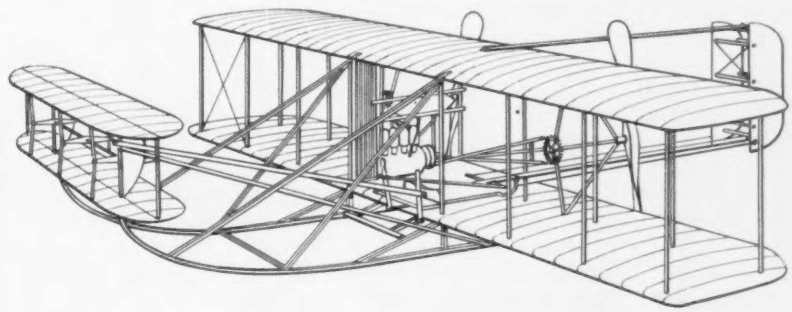
RT TECHNOLOGY
H THE AGES

(*Left*) Lock at Brandenburg, 1548–50. From "A History of Technology", vol. 3, Fig. 284.

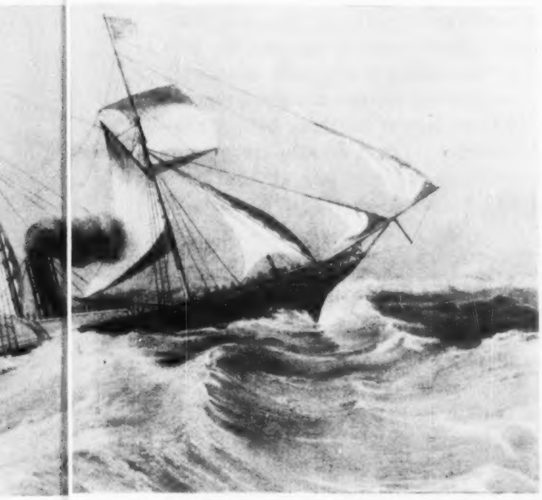
(*Below*) The *Great Western*, 1837, designed by I. K. Brunel. Although she was a wooden ship of 1350 tons, Brunel stressed in his design great structural strength, adequate engine power, and a supply of fuel estimated to last twenty-six days. Therefore he was able to cut down the ship's rig to that of a schooner, with four masts. She could easily steam at 12 knots. From "A History of Technology", vol. 4, Plate 44a.



(*Above*) Crampton patent locomotive *Komet*, built by the Karlsruhe Engine Works for the Baden State Railway in 1854. It had Hall cranks with outside Gooch link motion and the valves on top of the cylinders. The bogie was equalised. Boiler feed was by force-pumps worked by the piston tail-rods. From "A History of Technology", vol. 5, Fig. 170.



(*Below*) The 1908 Wright Biplane. The original *Flyer* of 1903 was very similar. Control was by the double front elevators (on the left), wing-warping, and the double rudder at the rear. From "A History of Technology", vol. 5, Fig. 204.



The former provided the very considerable endowment essential for planning and editing so substantial a work, and the latter have printed it at the very high standard that one has come to accept as a matter of course for the Oxford Press. The editorial work was originally entrusted to Prof. Charles Singer and Dr E. J. Holmyard. As the work progressed, they were joined first by Dr A. R. Hall and then by Dr Trevor I. Williams. This kind of project naturally involves an immense amount of attention to detail, and to make this possible ICI set up a small permanent unit to assist the editors.

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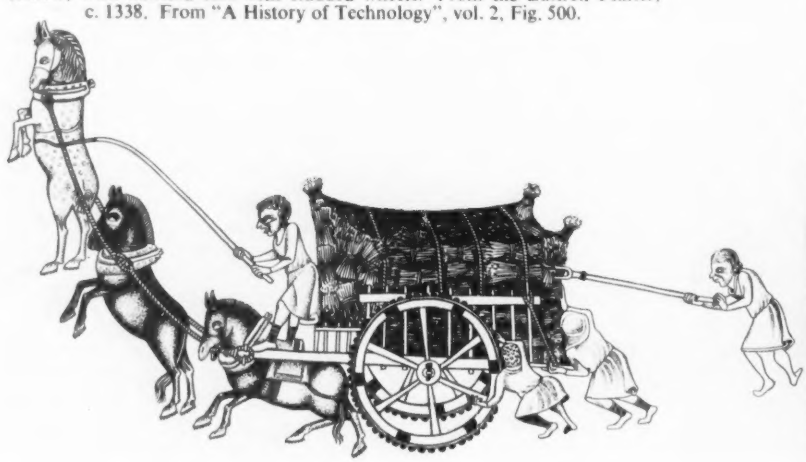

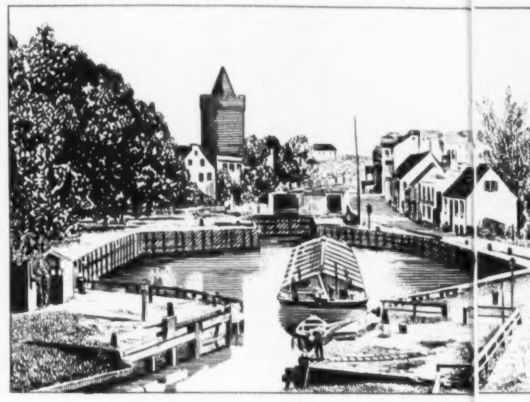

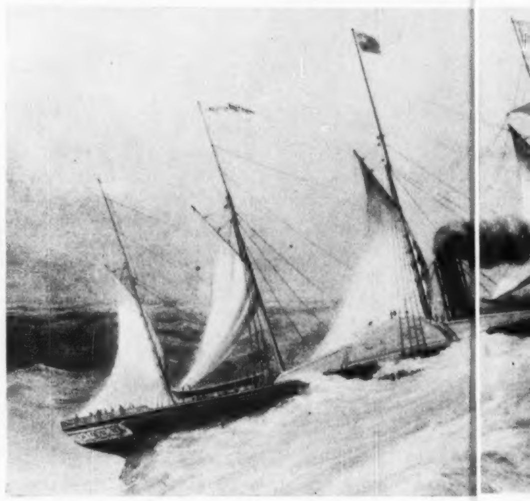

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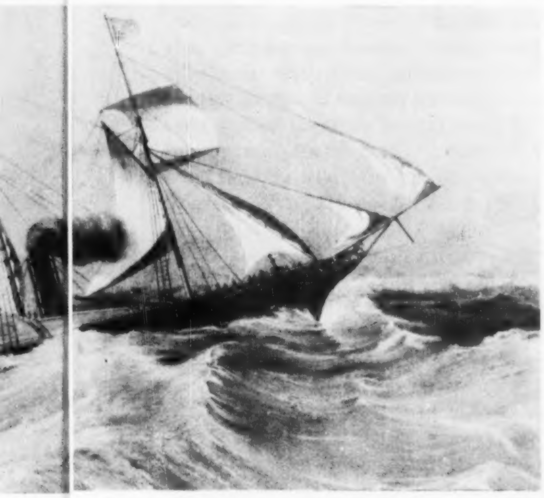

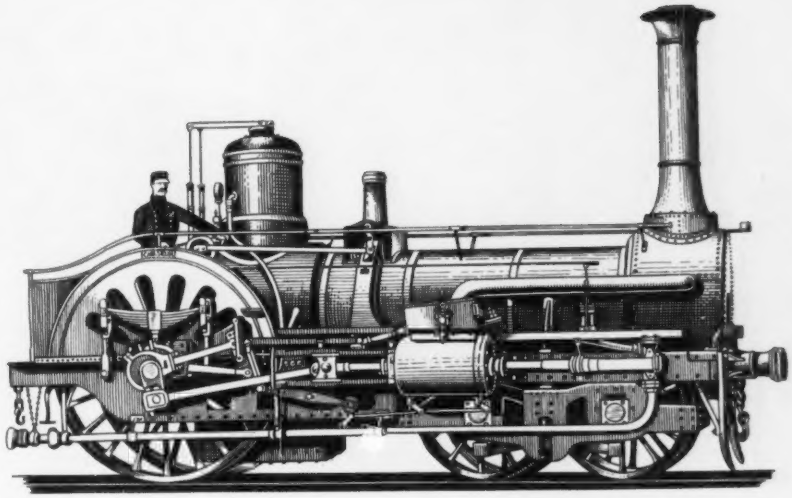

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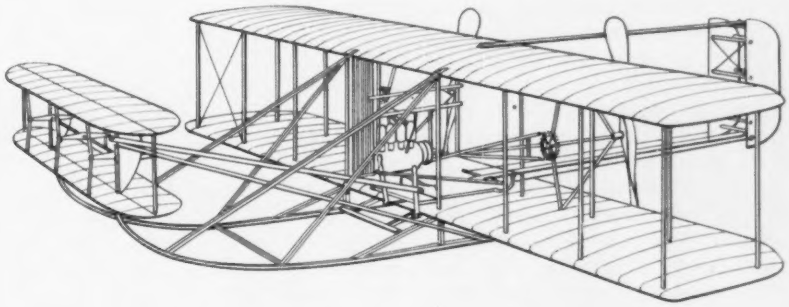

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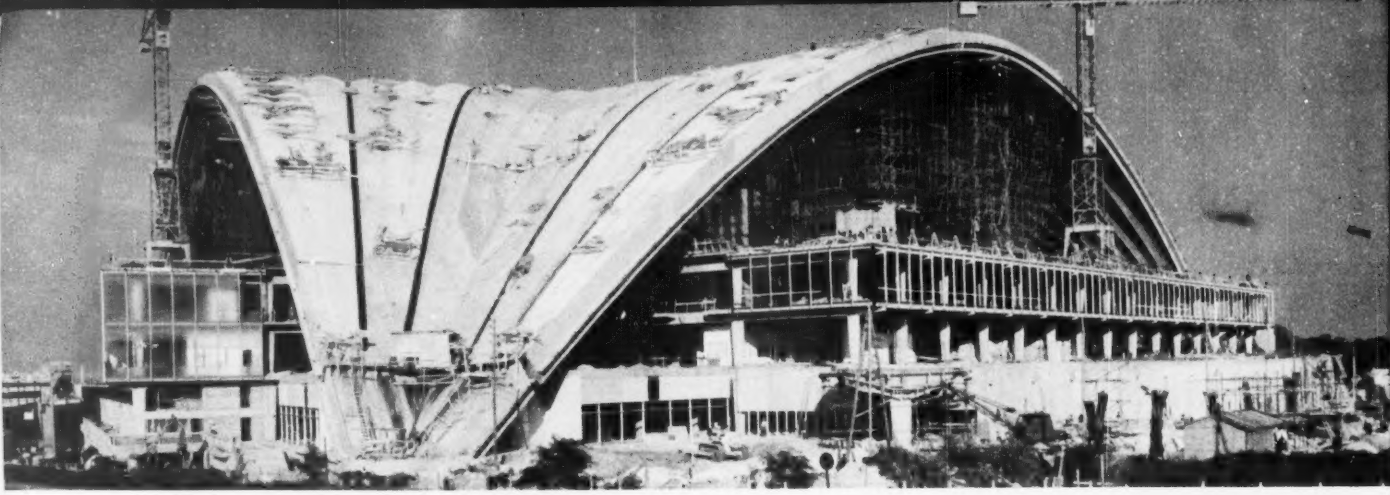


A FRENCH WORLD RECORD IN CONCRETE

The newly completed Exhibition Hall of the Centre National des Industries et des Techniques (National Centre of Industry and Technology) at the Rond-Point de la Défense in Puteaux, a suburb of Paris, has recently held its first exhibition. This building, with its 1,000,000 sq. ft. of floor space, will offer the possibility of organising international displays, until now held mainly in other countries which were better equipped than France for this purpose. Its completion marks a great step forward in the technical development of reinforced and pre-stressed concrete. Its appearance alone makes it a considerable attraction and testifies to the bold and inventive spirit of French engineers.* The three architects who designed the Exhibition Hall were Messieurs Camelot, de Mailly, and Zehrfuss; all three are recipients of the Grand Prix de Rome. The technical direction of the construction was the responsibility of Monsieur N. Esquillan.

The building of this project was started in May 1956 and it has required 3,600,000 cu. ft. of excavations, 1,440,000 cu. ft. of concrete, and 3000 tons of steel. The problem was to make the best possible use of the shape of the acquired site: an almost equilateral triangle measuring about 820 ft. at the sides. The idea of constructing a huge triangular dome requiring only three points of support, at once appeared as the most rational and spectacular conception, thus giving the work its monumental character.

For two years a team of engineers belonging to the three contractors tried to find, from calculations and experiments, which structural shapes could be used for the dome. It was then left to the architects to select from the solutions proposed by the engineers and imposed by the laws of physics the one which would satisfy the requirements of aesthetics, durability, strength, convenience, and harmony.

The conception, as it has been carried out by the three contractors, presents a remarkable achievement. The Exhibition Hall offers an area of about 320,000 sq. ft. at ground-level, and includes 700,000 sq. ft. of reinforced concrete floors.

These floors, which can bear very heavy loads, were built in less than fourteen months, at the rate of 50,000 sq. ft. a month. They were prefabricated in a specially erected factory 4 km. from the building site. The most interesting of these floors is made of pre-stressed concrete: it is hollow, covers a triangular area of 110,000 sq. ft. without expansion joints, and takes its support from posts inserted in a triangular grid, each side of which measures approximately 60 ft.

The dome rests on the three points of an equilateral triangle measuring 720 ft. at the sides. Covering a flat area of 210,000 sq. ft., it represents the greatest span for a thin dome of reinforced concrete existing in the world today, as well as the greatest area held up by single points of support.

The reinforced concrete simultaneously assumes the role of structure and roofing; the roofing is self-supporting, with the stress lying on the supporting corners along converging lines. It is made up of three fans of eighteen hollow box-frames in reinforced concrete. These frames spread out from each abutment within an angle of 60°, support each other at a height of 170 ft., thus forming three massive tympani.

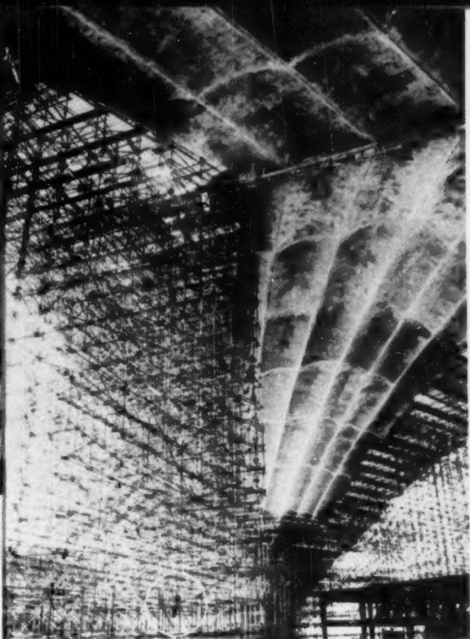
The box-frames are made up of two corrugated shells with a thickness of $2\frac{1}{2}$ in. over the greater part of their surface. These shells are kept at a distance of about 7 ft. by a network of vertical counter-braces which are at right angles to the walls and radiate from the abutments and cross-tympani.

Thus this structure is akin to that of aircraft fuselages and wings, all of whose characteristics it possesses: lightness, an exceptional resistance to bending, twisting, buckling, and to static and dynamic stresses. In addition, the empty inner space with room for the heating and lighting systems is also a great advantage.

The ingenuity of the methods used to achieve this result also deserves attention. For the scaffolding of the work 600 miles of metal tubes were required, an amount difficult to find in France. The engineers therefore decided to carry out the construction of the dome in three successive stages. It was foreseen that each third of the roofing would develop fanwise from the central groin to the tympani of the façade. Thus, during the course of its construction the dome began to look like a star whose three arms continued to spread. This system made it possible to reduce the mileage of tubes required for the scaffolding from 600 to 175.

The side walls, made entirely of plate glass and covering a total area of about 180,000 sq. ft., are supported by a light metal frame, mostly made of stainless steel. The linking of these two structures, concrete and metal, includes special devices required to ensure the free play of the one in relation to the other.

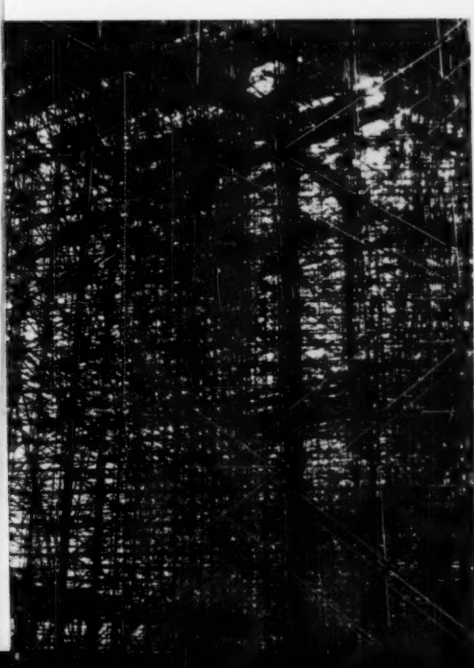
* See also page 522.

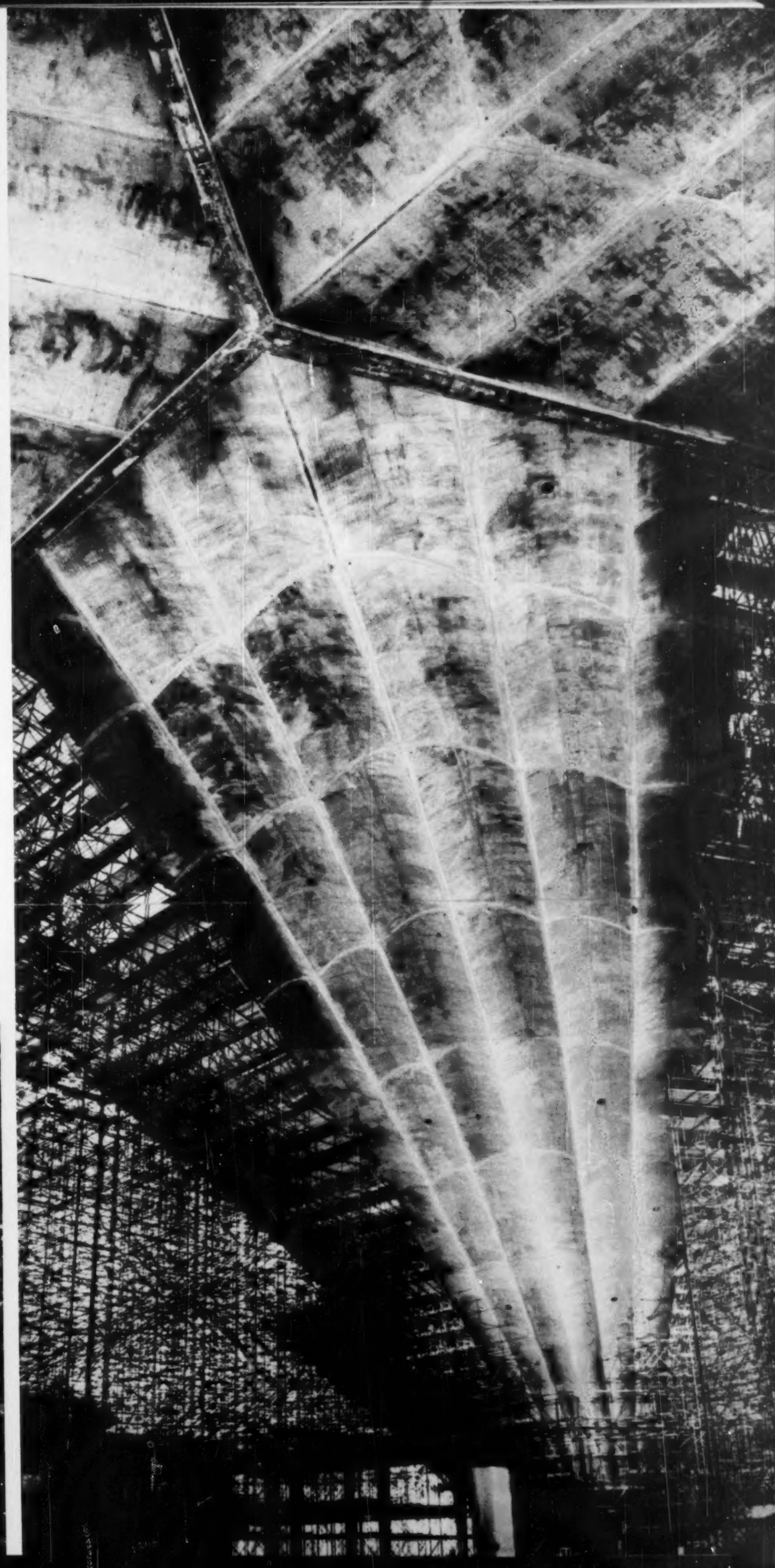


(*Above*) Note the size of a man (in white circle) in comparison to the scaffolding and building.

(*Right*) One of the points on which the dome rests.

(*Below*) General view to show the amount of scaffolding used.





PROGRESS AT HINKLEY POINT

Hinkley Point Atomic Power Station, which is being built for the Central Electricity Generating Board by the English Electric, Babcock & Wilcox, and Taylor Woodrow atomic power group, is the largest atomic power station in the world (500 MW) now under construction.

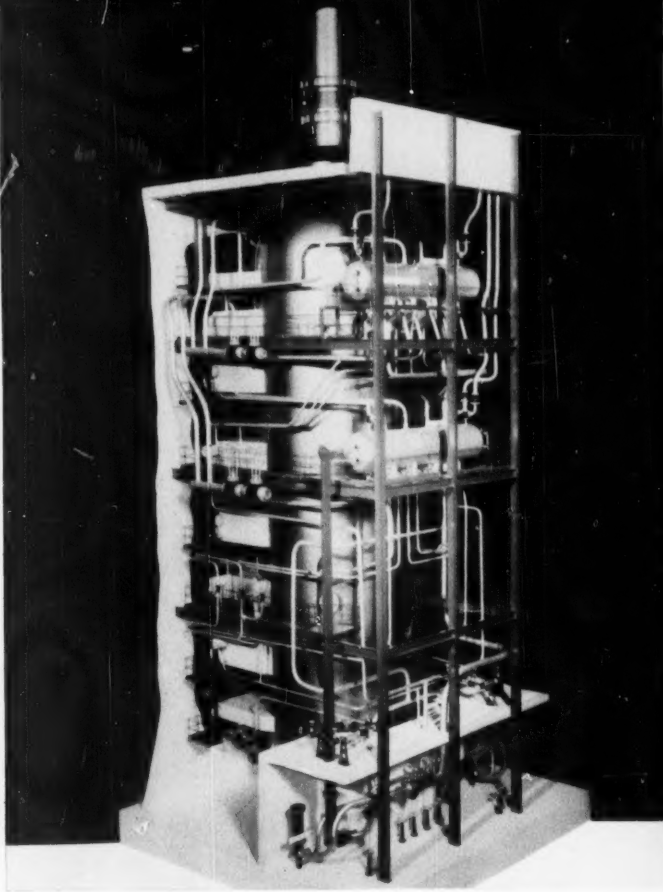
When the station is completed in 1962, the two reactors will each have six steam-raising units, giving a total steam production capacity of 5½ million lb./hr., supplied to six main turbo-alternators each of 93·5 MW rating and to three variable-speed turbo-alternators supplying the gas circulator drives.

The initial task on the construction site involved the removal of 200,000 cu. yds. of soil and clay excavation to form the general station level at +36·00 ft. O.D. By use of fast-moving scraper equipment, this was practically completed by early January 1958, enabling the excavation in rock for the reactor foundations to start that month. Some 32,000 cu. yds. of rock excavation have been taken out for foundations of reactors Nos. 1 and 2, as well as deep excavations for the blower house.

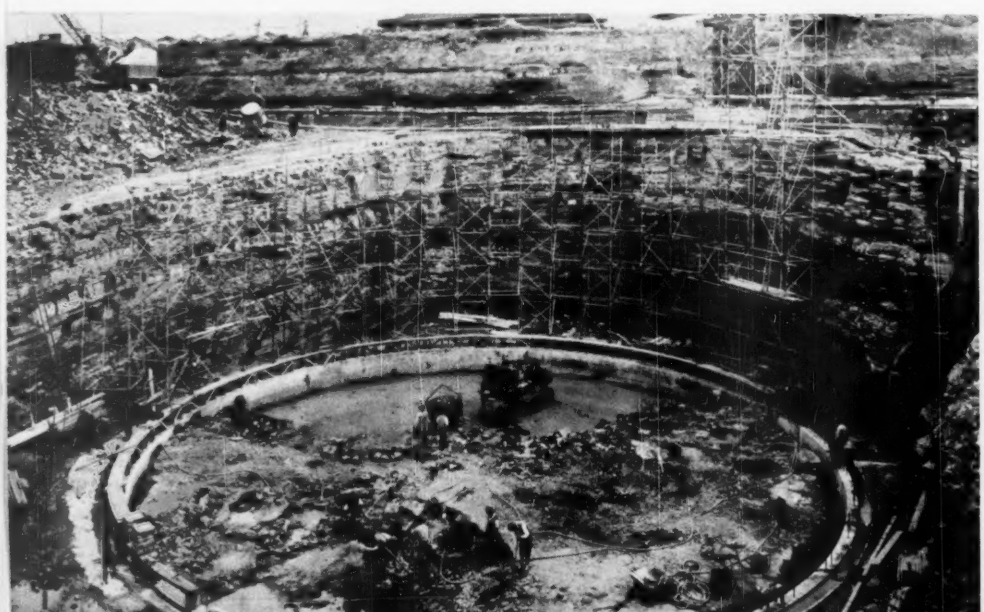
By the beginning of October 1958 approximately 900 tons of reinforced steel had been used in the foundations and walls of reactor No. 1, and some 22,100 cu. yds. of high-quality concrete placed in the shield and foundations. On this reactor the main biological shield construction was about 85% complete, and the secondary shield approximately 60% complete. Concreting in reactor No. 2 foundation started late in June and some 4700 cu. yds. have been placed to date.

The reinforced concrete subway for conveying the high-voltage cables from the turbine house to the 275-kV switchgear compound, south of the main station site, is approximately 80% complete.

A system of roads, giving access to the whole site, has been in operation since the end of May.

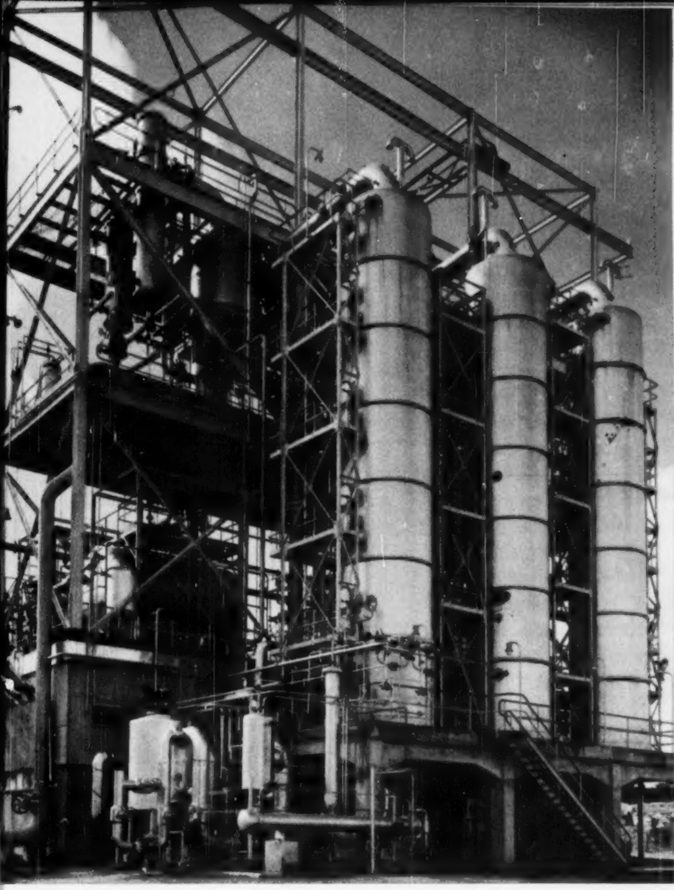


(*Above*) Sectioned model of one of twelve 90-ft. high steam-raising units for Hinkley Point nuclear power station.



In the 60-ft.-deep dry dock area, protected from the sea by a steel piling cofferdam, the cooling water intake structure will be built. The photograph shows the circular concrete footing being constructed ready for the erection of the cooling water intake caisson.

BRITISH SYNTHETIC RUBBER PLANT

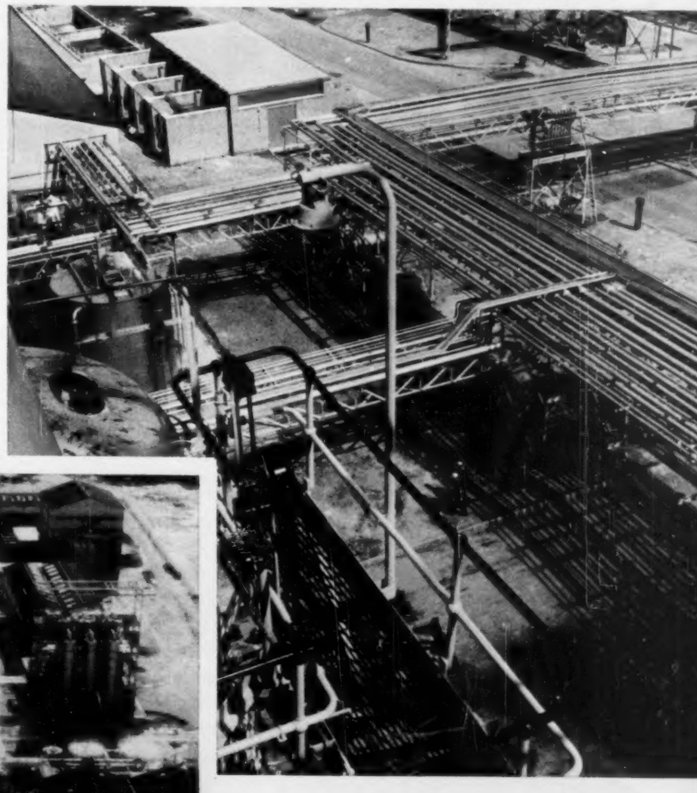


The plant is owned by the International Synthetic Rubber Co. Ltd, who are also the designers. It produces general-purpose butadiene-styrene copolymers via a low temperature, "cold", emulsion polymerisation reaction (41°F).

The various solutions required for this reaction are made up in a special make-up area, and then, together with the butadiene and styrene, charged to the reaction system. When a predetermined proportion of the monomer charge has been reacted, the polymerisation is short-stopped and the resulting latex passes to the recovery system where the unreacted butadiene and styrene are removed from the latex. The stripped latex is then blended, and an oil extender, if required, is added as an emulsion.

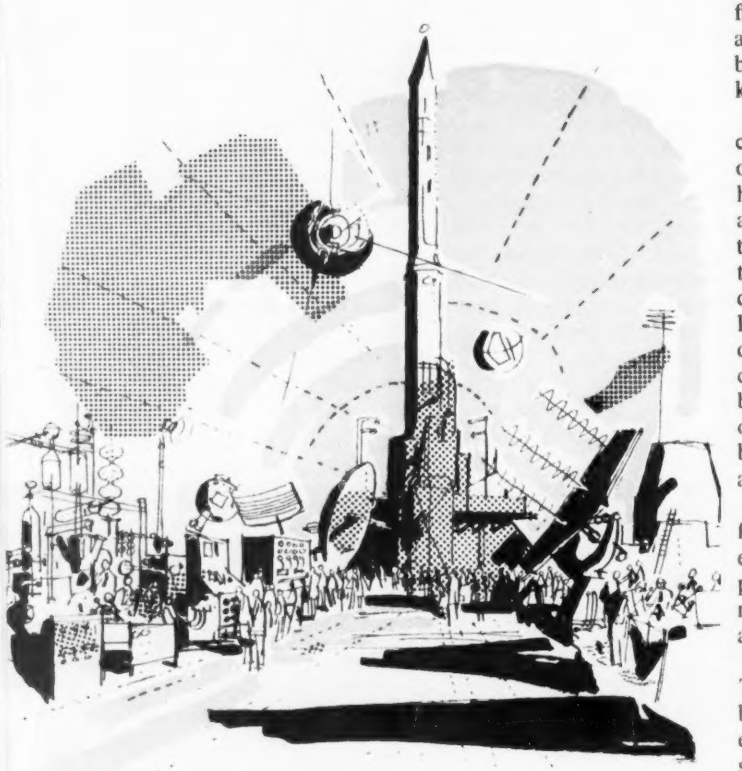
The next step is the coagulation of the latex to yield a slurry of rubber in aqueous liquor. This slurry is filtered and washed, and the crumb is dried and finally compressed into bales. These bales are sold mainly to tyre manufacturers, who blend the synthetic with the natural raw material in the ratio of 45 to 65.

(*Above*) The new £6 million synthetic rubber plant, which was built in sixteen months at Hythe, Hants, with a capacity of at least 70,000 tons. It is now in full stream production.



(*Above*) Pipetrack—from Styrene Stripping Columns—of the new synthetic rubber plant.

(*Left*) Aerial view of the new synthetic rubber plant.



The Avenue of Discovery

EXHIBITION OF PUBLICITY FOR SCIENCE

A new organisation, International Scientific Research Exhibitions Ltd, has been formed in London for the special purpose of promoting public interest in scientific research and its results. Its first exhibition, to be held at Olympia in October 1959, will be built around the simple yet often overlooked proposition that research is at the roots of our industry and hence of our complex and advanced civilisation. This will be the first time in the history of commercial exhibitions that science has been the main item of display. Contributions from industry in this country and abroad are to be presented within the framework of their relation to research and technological development; the sprawling formlessness which characterises most exhibitions will thus be eliminated. This provision of unity and a sense of purpose, ISRE believe, will gratify the visitor and benefit the participating industry.

The central aisle of Olympia, to be called "The Avenue of Discovery", will be bordered with displays from the laboratories of industry, co-operative research organisations, and the universities. This is the starting-point, representing "the hard core of basic research". Purely commercial displays will branch out from the Avenue, and the visitor can work towards the periphery of the ground floor while tracing the various stages of development of any number of products. In doing so, he will learn how basic research on polymers, for example, resulted in many kinds of plastics and man-made fibres.

Indeed, one of the most pleasing aspects of the ISRE conception is the emphasis on education. Not only do the organisers, through the general structure of the exhibition, hope to explain to the visitor the relation between science and the world in which he lives and buys his daily bread, they hope further to enlarge his store of scientific information by means of free films and lectures to be presented daily. A wide range of subjects will be covered, and each lecture will be presented in a variety of ways, from popular discourse to scientific exposition, so that lay visitors from different age-groups and with varying degrees of scientific background may be reached. Also, the academic display on "The Avenue of Discovery" will permit the public to become more familiar with this relatively little-known aspect of university life.

The Gallery at Olympia will be given over entirely to firms manufacturing scientific instruments and laboratory equipment. Although this special display is intended primarily to introduce the research scientist to some of the most up-to-date equipment in his field, it will be open to any interested member of the public.

Four important technical achievements: Power, Materials, Transport and Communication, Health and Food, have been chosen by special advisory panels as themes for the exhibition in October. These panels consist of leading scientists, designers, and industrialists, and will make the final selection of displays. Universities in this country and abroad will be approached for contributions to the academic section, and participating firms will be asked to show how research in their laboratories is related to these themes.

The creation of a private company to function, in effect, as a publicity organisation for science, is mainly the work of three men, one of whom is himself a scientist with considerable experience in presenting science to the public. They were motivated, in part, by the need to rectify the general view which sees research as a vague area of activity unrelated to daily life. Next October's exhibition is the model which will be followed in each annual exhibition to come. The themes of future exhibitions will vary, so that over the years a comprehensive picture of the differing aspects of scientific research will be built up.

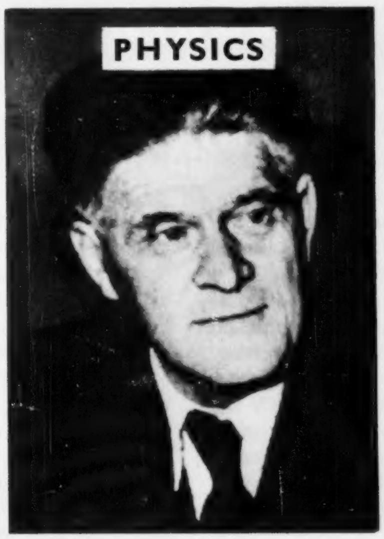
The type of exhibition designed by ISRE should appeal to commercial organisations because their products will be presented organically rather than as accidental amputations of commerce. ISRE hope their design will also communicate to the public some of the sense of excitement and adventure which the scientist feels in carrying out research, and thereby stimulate genuine curiosity. This is an idea worth watching, as it should do a great deal to lessen the gap between science and the public; a gap due almost as much to science's aloofness as to public ignorance.

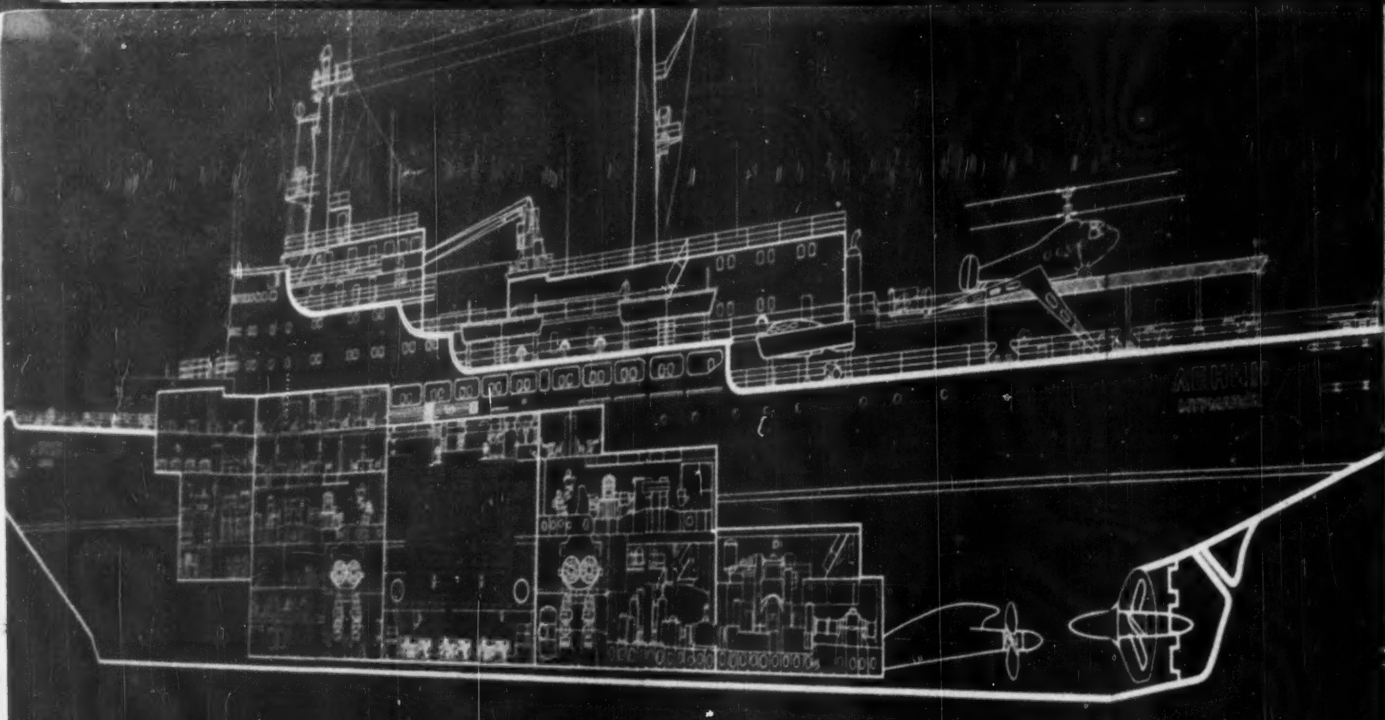
NOBEL PRIZE WINNERS 1958

It is again with pleasure that we announce the recipients of the Nobel Prize. The winner of the chemistry prize is forty-year-old Dr F. Sanger, F.R.S. (*left*), of Cambridge University. As we said in our Editorial of December 1956, p. 523, and March 1957, p. 89, the Nobel Prizes should go to young scientists with a brilliant career ahead of them, instead of behind them. This was Nobel's intention when leaving his money. Dr Sanger's work was concerned with the determination of the chemical structure of insulin.

The Nobel Prize for physics is shared among three Russian scientists, Prof. I. M. Frank (*below, left*), Prof. Cherenkov (*below, centre*), and Prof. Igor Tamm (*below, right*) of Moscow. Cherenkov radiation is now a well-known phenomenon (DISCOVERY, 1957, vol. 18, p. 145), and it is due to electrons moving through a liquid at a speed exceeding that of light in that medium.

The prize for medicine is shared among three American scientists, Prof. George Wells Beadle of the California Institute of Technology (*bottom, right*), Dr Edward Tatum of the Rockefeller Institute in New York (*bottom, centre*), and Dr Joshua Lederberg of the University of Wisconsin (*bottom, left*). They have put on a firm experimental basis the long-standing belief that the effect of a single abnormal gene in genetic inheritance of a species makes some single step in the chain of biochemical processes abnormal.





THE RUSSIAN NUCLEAR-POWERED ICE-BREAKER *LENIN*

A. P. ALEXANDROV, I. I. AFRIKANTROV, A. I. BRANAUS, G. GLADKOV, B. V. GNESIN, J. I. MEGANOV, N. S. KHLOPKIN

The American submarine *Nautilus* was the first ship of any kind to steam out of any port with nuclear power as the sole means of propulsion; and since the *Nautilus* a number of other submarines built in the United States have been commissioned and have successfully completed arduous trials. The recent passage of the *Nautilus* under the North Pole, one of the outstanding feats of navigation in the whole history of the sea, has indicated clearly the reliability of the nuclear-powered propulsion mechanism.

Although several other nations are actively engaged in planning nuclear propulsion equipment for surface ships, only the Soviet Union has a full-scale installation in the course of actual construction. On December 5, 1957, the *Lenin*, an ice-breaker with a displacement of 16,000 tons, was launched from a dockyard in Leningrad, and she will probably make her maiden voyage within the next twelve months. The *Lenin* is over 700 ft. long and is more than 80 ft. wide.

It might be thought that nuclear power has obvious advantages for all types of maritime installations only when the cost of the power plant is economic; that is, comparable with the cost of propulsion by other methods. However, there are special cases where economic advantage is not the ruling factor. For the American submarines the military advantages obviously outweigh any economic considerations, and a recent cruise by the *Seawolf*, which stayed submerged for 54 days, needs no comment in this connexion.

In the case of the Soviet ice-breaker the advantages to be gained by nuclear propulsion outweigh the economic disadvantages of very high first cost: any ice-breaker, to be capable of performing its function, needs to be free of the land for the longest practical period. Existing coal- and oil-burning vessels of this type need relatively frequent bunkering, and therefore their operation is restricted to a comparatively narrow coastal strip. Moreover, ice-breakers by the very nature of their work, are liable at any time to become temporarily embedded in the ice for periods of uncertain length, and thus in the past they have had to proceed with the utmost caution for fear that fuel reserves would run out.

A nuclear-powered ship could, at any rate theoretically, operate without contact with land for months or even years at a time; and indeed it is possible to imagine an ice-breaker working through the whole of the winter season without once needing to return to port if equipped with a suitable nuclear power plant. The *Lenin* is stated to be self-sufficient for at least twelve months.

PROBLEMS OF DESIGN

The problems facing any naval architect who wishes to install a nuclear reactor on board ship are considerable. First, he must find a type of reactor with the minimum deadweight and the smallest possible dimensions.

The reactor shielding has its own severe problems. Land-based reactors can be designed so that large masses

of concrete, in practice unlimited in thickness, can be installed to provide perfect safety against radiation dangers to the personnel and to others. On a ship, the shielding must obviously be restricted in weight and dimensions. This factor conditions the type of reactor to be installed.

The possible danger of damage through collision must greatly exercise the mind of the designer of a nuclear reactor for shipboard use, and he must try to find solutions to problems of a totally new character. Again, there is always the possibility of discharging into the sea some sort of radioactive material, and this must be guarded against at all costs. The reactor must be designed so that local maintenance work can be carried out at sea, and again techniques new to marine engineering have to be employed. The crew accommodation must include room for a number of scientists in addition to the normal complement of a ship of this type, and moreover there must be provision for laboratories for checking radiation levels and radiation doses, and for reactor checking and control. Finally, in this list of problems, mention must be made of the need to provide a type of nuclear reactor which can withstand the heavy rolling and pitching which any ship could, under certain circumstances, be expected to encounter.

On the credit side there is first and foremost the reduction in weight available with a nuclear plant, when it is compared to the conventional methods of providing power for ships. A 20,000 shaft horse-power tanker, with a deadweight of 40,000 tons, uses 500 barrels of oil fuel a day, and its power plant and fuel load weigh about 4200 tons. A nuclear power plant for the same ship would weigh about 3650 tons, the reactor accounting for 600 tons of this figure, the containment and shielding equipment 1900 tons, and the propulsion system 1150 tons. The second great credit item is the ability of such a ship to operate for extended periods at sea without refuelling, as mentioned above, thus increasing its economic utilisation.

Apart from specialised military use, the high cost of nuclear propulsion equipment is likely to mean that it will only be applied, in the next decade or so, to special ships like the *Lenin*, or to very large ships such as giant 100,000-ton tankers, where the economic advantage would become significant.

CHOICE OF REACTOR

Having decided on a nuclear propulsion system, the U.S.S.R. engineers were obviously faced with the choice of the most suitable type of reactor. There are at present eight types of reactor, either in use or under construction or development for generating power. The largest power programme, in Great Britain, utilises the type of reactor in which natural uranium is used as a fuel and the flow of neutrons in the reactor core is moderated by graphite. The heat resulting from the controlled nuclear fission reaction is carried away by a forced flow of carbon dioxide gas, which enters heat exchangers where steam is generated, and the steam drives the turbines. Britain and France are using this type of reactor for their power-production programmes.

American and Russian power-producing reactors use enriched uranium, whereby the naturally occurring uranium metal is chemically treated to produce an excess of the only part of it capable of sustaining a chain reaction, uranium 235. This process of enrichment is extremely expensive, but the United States and Russia are fortunate in having large enrichment plants primarily built for military purposes. With the use of enriched uranium it becomes possible to build a reactor either of the pressurised water or boiling water types.

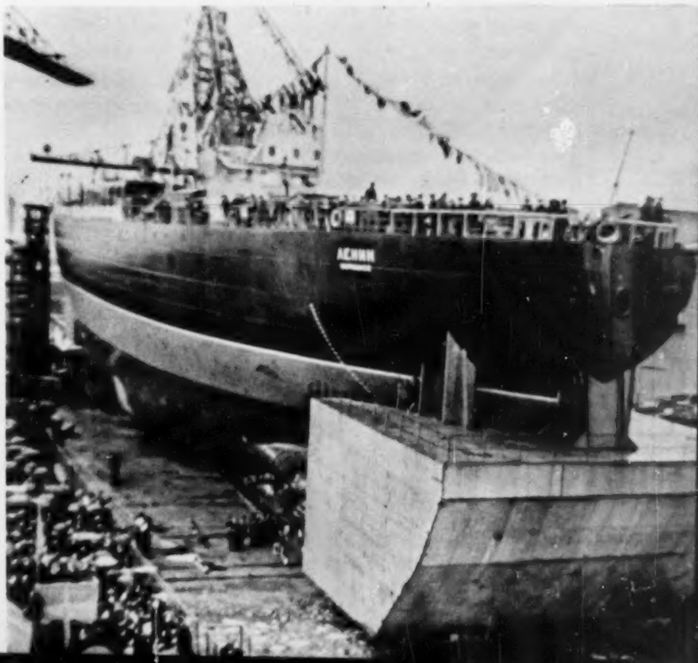
In the pressurised water type of reactor either heavy water (which is expensive) or natural water can be used as the moderator; but as ordinary water captures more neutrons than heavy water, it needs a fuel with a greater degree of enrichment, producing more neutrons. In this design the fuel elements, of enriched uranium, are situated in a containing vessel, and cooling water, which also acts as a moderator, is forced through them under pressure. This water, heated by the nuclear reaction, is taken to a heat exchanger, or boiler, where it causes the water in a secondary system to turn into steam to drive the turbines.

A boiling water reactor could also be used, and here the core is immersed in a vessel partly full of water; the heat from the reactor causes the water to boil and to be used either directly as steam, to drive the turbines (in which case the turbine is included in the radioactive area), or else it is taken to another type of heat exchanger to produce steam in radioactive-free water.

The advantage of the pressurised water reactor for nuclear propulsion, as used in the United States submarine *Nautilus*, the Shippingport nuclear plant in the United States, and in the ice-breaker *Lenin*, is the relative smallness of the dimensions of the reactor and its stability and flexibility in operation. The disadvantage is the low temperature of the steam produced, which tends to limit the efficiency of the turbines and involves certain constructional problems in the turbine design.

The British "Calder Hall" type graphite-moderated gas-cooled reactor could not be used in the ice-breaker, as its weight and dimensions, for the smallest practical unit, would be too great. The boiling water reactor, although it has certain operational advantages, has not been developed sufficiently in any country to enable reliance to be placed on its stability of operation, thus the choice of reactor automatically fell on the pressurised water type, a

FIG. 2. Launching of the *Lenin*, December 5, 1957.



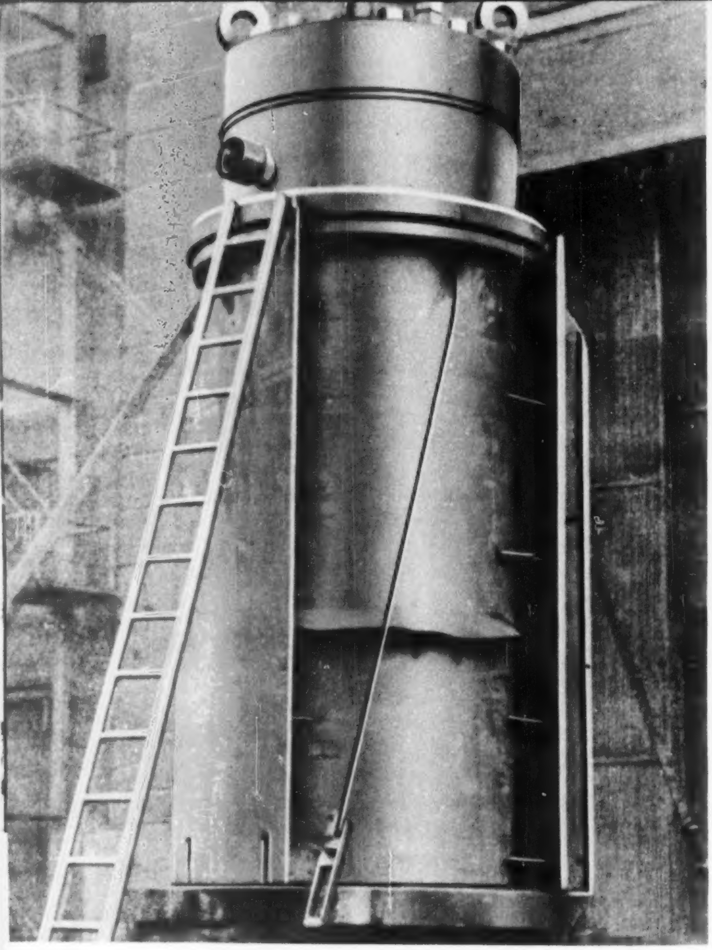


FIG. 3. Reactor before mounting in the ice-breaker.

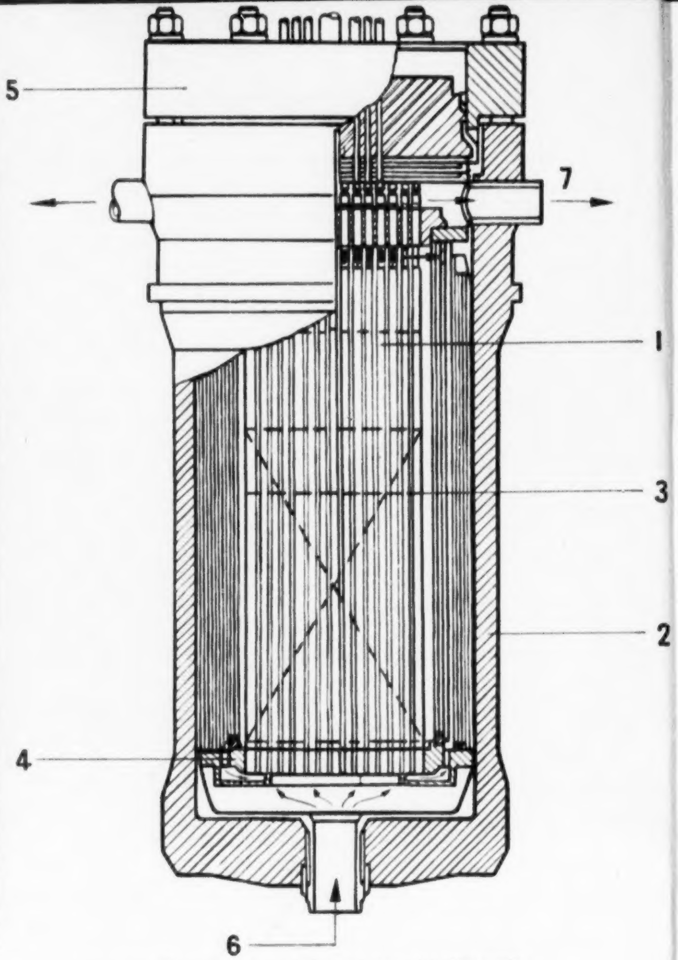


FIG. 4. General view of the reactor: (1) Channels. (3) Pressure vessel. (3) Shielding. (4) Louver plate. (5) Cover. (6) Inflow of working medium. (7) Outflow of working medium.

decision, as mentioned above, similar to that made in the United States for the range of submarines already built and now under construction.

THE *LENIN* REACTOR

The *Lenin* is equipped with three reactors, although, from the point of view of reducing the weight and size of the steam generating plant, it would have been more advantageous to install only one reactor in the *Lenin*. However, in the case of a ship of this type, the dictates of reliability indicated that it should be equipped with at least two independent sources of power. It was finally decided to install a third, or reserve, reactor, thus enabling all three to operate under optimum conditions. The third reactor is only to be used in conjunction with the other two under the worst possible ice conditions, when maximum power is required for lengthy periods. The use of three reactors enables the ship to proceed normally if any one of the three should suffer a breakdown, and it also enables maintenance work to be carried out on any of the three with much greater ease than would be the case if two reactors only were installed.

The reactors use enriched uranium in the form of sintered uranium dioxide, canned in a zirconium alloy, in a reactor core of about 1 m. in diameter and about 1·6 m. in height. To regulate the output of each reactor, in which there is about 85 kg. of 5% enriched uranium, control rods are introduced from above, causing a distortion of the neutron field along the height of the core.

In each reactor, cold water enters at the bottom of the pressure vessel containing the core. This vessel has an outer diameter of about 2 m. and its height is about 5 m. It is made up of low-alloyed, high-strength carbon steel, with an internal stainless steel shell to protect it from attack by the high-temperature water.

The water flows upwards through the reactor and into the two steam generators, or boilers associated with each reactor unit.

The steam generating equipment consists of three self-contained sections, each section including a reactor and two heat exchangers, together with all the pumps and auxiliary equipment required for its operation.

When ready for operation the nuclear steam generating plant, including the biological shielding, weighs 3017 tons, and the total horse-power available from the main generators is 44,000 h.p., the specific weight of the installation being 68·5 kg./h.p.

The pressurised water circuit of each steam generator includes the passage through the reactor and the steam generator and two main and one auxiliary forced circula-

tion pumps; there is also a volume compensating device to allow for expansion, and a filtering unit.

The circulating water-pumps of the main reactor circuit set up a pressure of 200 atmospheres. Each pump is of the centrifugal type and is completely cased in with its own electric motor, which is of the squirrel-cage type and has a rating of 250 kW. The main pump output is 500 cu. m./hr., and thus the water flow in the reactor has a maximum level of 1000 cu. m./hr.

To allow for maintenance to any part, valves are provided to cut off either of the two circulating water loops associated with each reactor from the reactor itself; while a section is under maintenance, the reactor operates at reduced capacity.

The rated steam output is 360 tons/hr., achieved with full load on all reactors. The steam is at a pressure of 29 atmospheres with a temperature of 310°C, and the temperature of the water entering and leaving the reactor is 248°C and 325°C respectively.

IMPORTANT SAFETY DEVICES

The first and perhaps most vital safety problem to be mentioned is that of ensuring that the heat generated by the nuclear fission operation in the reactor is continuously removed by the coolant. Although the control rods would operate instantly if the cooling water should fail, the "heat inertia" of the core and the vessel would be such that considerable damage would be caused.

To prevent this occurring, there are two main pumps for each circulating water loop, and either of these can carry full load. They are supplied from separate power systems. There is, in addition, an emergency pump on each loop, which is brought into action automatically if the other two should fail.

If a fuel-can should burst, highly radioactive materials would be released into the cooling water circuit, with serious consequences. To obtain early warning of this possibility, an extensive series of probes is provided in both primary and secondary water circuits, and these "feelers" are connected to recording gear and to alarm circuits. The seals between the primary (potentially radioactive) water circuit and the secondary (normally non-radioactive) water circuit are thus continuously supervised.

Next in the safety scheme is the design feature which causes the core to have a negative temperature factor in the region of the operating temperatures. This means that the higher the temperature, the less the reactivity; but a moderate value for this factor has been chosen since, if it were too high, when the temperature falls during normal operation a considerable amount of excess of reactivity would have to be dealt with, and this would mean the control rods would be considerably larger and heavier.

The third safety feature is the provision of safety rods, which can be introduced into the core in 0·6 sec. for instant destruction of the chain reaction. These rods are introduced at the top and are driven from a motor, the drive incorporating a friction coupling controlled by an electromagnet. When the magnet circuit is interrupted the coupling is disconnected and spring drive causes the rods to drop instantly into the core.

The shielding is such that the radiation level around the reactor does not exceed 0·1 to 0·3 of the maximum permissible level for an eight-hour working day. All the rooms in the vicinity of the reactor and steam generating plant are provided with fixed dosimeters, which send alarm signals, not only to the control point but also to points situated near the entrances of these rooms, if the radiation level is exceeded.

FIG. 5. Latest available photograph, dated September 1958, showing the progress made in building the *Lenin*.

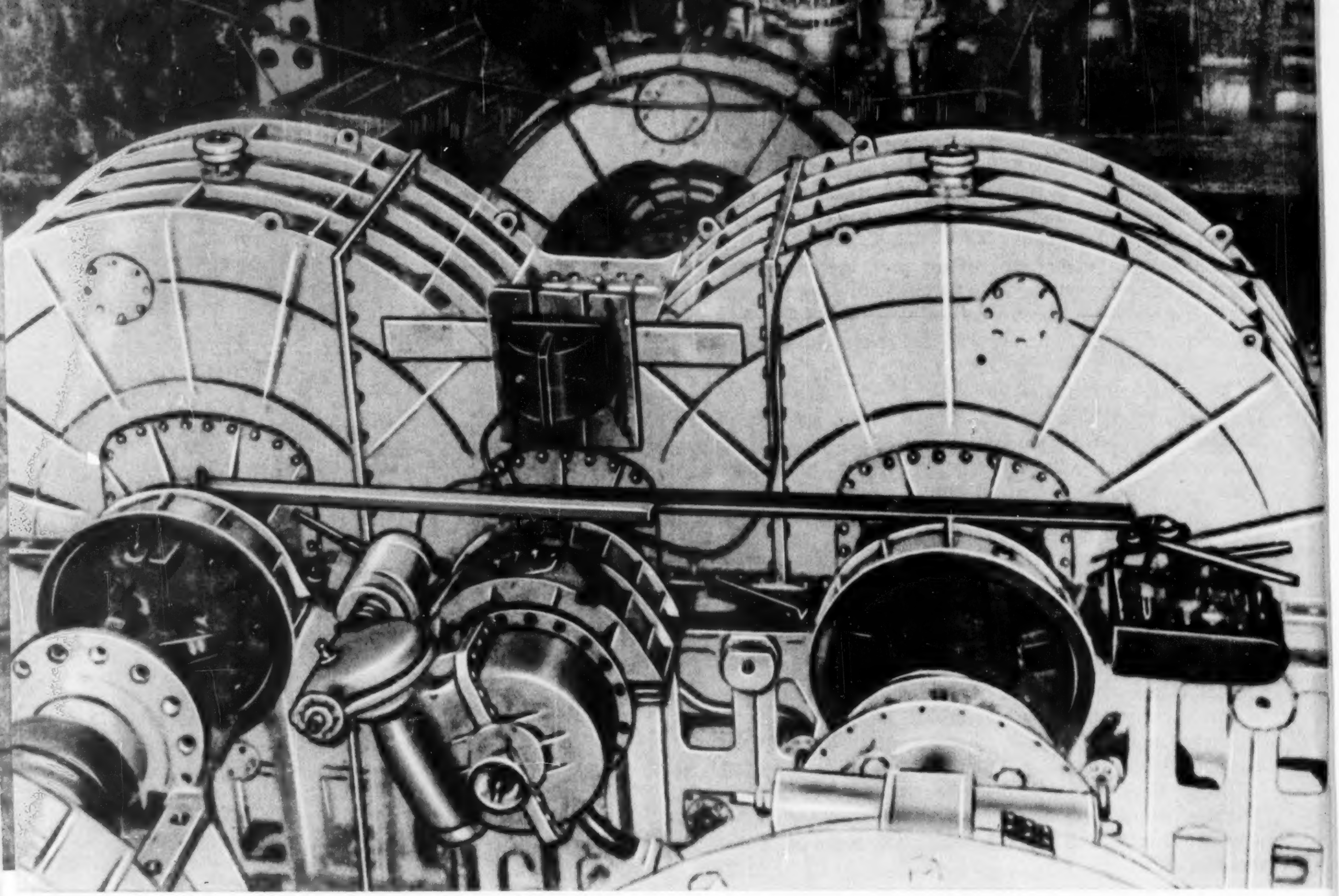
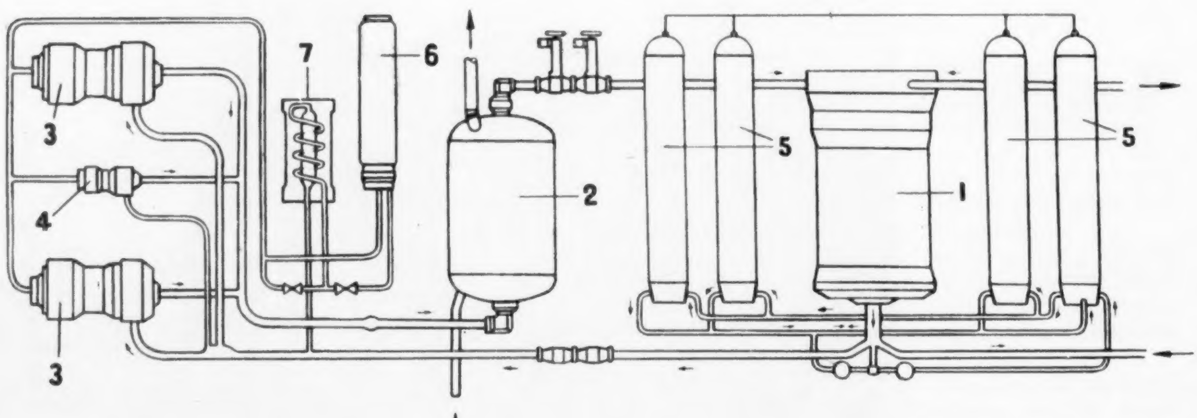


FIG. 6. (*Above*) Main turbo-generator. The reduction gear and turbine can be seen.

FIG. 7. (*Below*) Principal scheme for the steam generator portion. (1) Nuclear reactor. (2) Steam generator. (3) Main circulating pump. (4) Emergency pump. (5) Volume compensators. (6) Filter. (7) Filter cooler.



THE CHALLENGE

The design of the whole of the plant takes into account the fact that even the most strongly built ship could sink. The steam generating plant, designed for an operating pressure of 225 atmospheres, would remain undamaged down to very great depths of water if the ship foundered, thus preventing the contamination of the water by fission products.

Water in the main reactor steam generator circuit, which might become radioactive and has to be stored on occasion on the ship, is held in a specially shielded tank; it could be purified on board to a level of 5×10^{-9} curies/litre. It is envisaged that if this water has to be discharged it will only be done at the special service base provided for the ship. Nevertheless, if the water had to be discharged at sea, it would only be allowed to escape when it had reached a level of radioactivity not exceeding the maximum permissible concentration, in accordance with existing international standards.

METHOD OF OPERATION

The steam provided by three reactors and their steam generators is taken to four turbo-generators, each driving through reduction gears two direct current generators having an output voltage of 1200 volts—a high level for shipboard use. Direct current was used for the main propulsion system as it provided greater flexibility of control.

The ship is equipped with three screws, each driven by two motors and a reduction gear. The centre screw is driven by a motor of 19,600 h.p. and each of the two outboard screws have motors of 9800 h.p. Amplidyne control devices provide extremely flexible control of the generator and motor excitation circuits, the control equipment being triplicated for each propeller drive.

The control circuits enable the power from any generating unit to be applied to any driving motor group, suitable switching arrangements being provided. In this way the maximum manoeuvrability is obtained.

The propelling force is divided among the screws in the ratio of 1 : 2 : 1. With constant-pitch propellers it is not possible to provide optimum conditions for both steaming ahead and thrust when stationary, as into an ice-floe. Thus the screws are designed to give the maximum thrust when driving the ship into ice; and under these conditions the thrust developed equals 330 tons.

Auxiliary power for the main generating plant is provided by two independent plants each equipped with a 1000-kW turbo-generator, while there is in addition a 1000-kW diesel engine for starting the power plant when no steam is available. Other emergency power is provided from two 100-kW diesel engines, which are automatically started to provide power for the main circulating pumps and other equipment should the normal supplies fail.

OTHER INTERESTING FEATURES

Although the main interest in the *Lenin* naturally concerns the nuclear propulsion units, the ship has a number of remarkable features not specifically connected with nuclear propulsion, but related to the ship's ability to stay at sea for very lengthy periods at a time.

To increase the ship's efficiency as an ice-breaker, the installed power capacity, in terms of horse-power per ton, is greater (at 2·75) than the corresponding figure for any ice-breaker yet built. The U.S.S. *Glacier*, for example, has a ratio of 2·20.

What is described as a "new grade of highly resistant steel" is used for the hull, the outer skin being 36 mm. thick amidships, 52 mm. in the bow, and 44 mm. at the stern.

To allow the ship to negotiate seas encumbered with large ice-floes, there are special heeling and trimming systems. Tanks in suitable positions are emptied or filled by using pumps with reversible runners.

The ship is designed to have a very prolonged period of roll, of not less than 10 sec., and the pitching cycle is 7 to 8 sec. These figures are achieved by adjusting the metacentric height.

There are no less than eleven main transverse watertight bulkheads, making the ship virtually unsinkable, even if two sections are simultaneously flooded.

There is provision for a helicopter and its hangar at the stern of the flat deck. A 40-ton winch enables towing operations to be carried out.

FACILITIES ABOARD *LENIN*

In view of the long periods the *Lenin* may have to spend at sea under Arctic conditions, the accommodation for the crew is conceived on a lavish scale. Normally it is never necessary to go out on to the open deck to pass from one part of the ship to another. Single and double cabins, all provided with winter air-conditioning, hot water and heating are provided, and there are "daylight" lamps for use under Arctic night conditions. Provision is made for film shows, and there is a library, a "club room", a music room, and ample bath and shower accommodation. The medical suite includes radiation dosage measurement rooms as well as surgical, medical, and dental facilities, and a sick bay and an isolation ward.

The communication equipment is on an exceptionally lavish scale. There are ultra-short, short, medium, and long-wave radio channels, and both short-range and long-range radar installations.

The navigational aids include the usual gyro-compasses, logs and echo-sounders, and in addition there is an automatic course recorder, a direction-finder, and a radio co-ordinator.

The ship has a 100-station internal telephone system as well as separate telephone groups for vital services.

As the *Lenin* begins to breast the northern seas, at her full designed speed of 18 knots, a new era in naval architecture will be inaugurated.

(The Editor is grateful to Mr J. H. M. Sykes, a frequent contributor to DISCOVERY, *for preparing this article, which is largely based on a paper presented to the Second United Nations International Conference on the Peaceful Uses of Atomic Energy, and on other papers given at Geneva both in 1958 and 1955.)*

extreme measures was ever lawful in England. In contrast,

THE CHALLENGE OF LEPROSY

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FIG. 1. Advanced leprosy: although the disease itself would probably have been arrested for some time in the case portrayed here by the artist, deformity and mutilations due to paralysis and anaesthesia are progressive.
(Detail from "Trois oeuvres de miséricorde" Barent van Orley, Musée Royal des Beaux Arts, Antwerp)

"Leprosy is dreaded most of all diseases, not because it kills but because it leaves alive; not for its pain—though painful at times, the loss of pain and sensation is dreaded more. Mask face, unclosing eyes, slavering mouth, claw hands and limping feet; or even worse, beetling brows, stuffed nose, ulcerating legs and painful eyes drawing on towards blindness. . . . And over and above all this is the thought of the outcast, looked at askance by his once familiar friends, his name mentioned only in a whisper, a shame and disgrace to himself and his family."

The traditional picture of leprosy is expressed in the above quotation from Muir (1948).

HISTORY

Leprosy is a communicable disease peculiar to man and therefore theoretically capable of total eradication. Although it no longer merits the evil reputation outlined above, it seems to have been a significant problem for mankind as far back in time as we are able to penetrate with any certainty.

Owing to difficulties inherent in the interpretation of early medical writings it is not possible to be dogmatic about the origins of leprosy. The earliest certain description of the disease seems to come from India in the "Suskruta Samhitra" of 600 B.C. which even mentions treatment by an oil of Tuvarka—probably hydnocarpus. However, much earlier Indian writings, though containing less exact descriptions, probably include leprosy with other ill-defined diseases. It is therefore tempting to conclude that Asia was the cradle of leprosy rather than Africa—a view supported by the absence of typical lesions of leprosy in Egyptian mummies dating from 3000 B.C. and the absence of any definite description of leprosy in the Ebers papyrus of 1500 B.C.

On the other hand, such negative evidence is weak and may yet be reversed by the further study of ancient writings or remains. Moreover, from a consideration of the pattern of evolution of the disease in a given population, it is possible to argue that leprosy probably spread out from Africa through Egypt, eastwards to Asia, and westwards along the Mediterranean to Europe, and eventually the Americas.

In tracing its spread we are continually hampered by the uncertainty regarding nomenclature—for example, even Hippocrates (460–377 B.C.) himself described as leprosy a disease which was probably scabies. Among the early Mediterranean writers Aristotle (384–322 B.C.) gives the first definite description. Even the word "lepra" itself, which is Greek in origin, was not used originally by the Greeks to describe the disease now known as leprosy; they called leprosy elephantiasis.

ATTITUDE TOWARDS LEPROSY

It has been stated that no clinically recognisable description of leprosy exists in the Bible—yet the Biblical attitude towards "leprosy" has played a prominent part in fostering the attitude of the peoples embraced by Christendom and has tended to delay a rational and unemotional approach to the disease.

Being a disease of obscure origin and long duration, the stigmata of which are evident for all to see, it is perhaps not surprising that primitive peoples react emotionally towards the sufferers. The mechanism of this reaction has been analysed by modern psychologists and described in terms of a fear-guilt complex (Ryrie); leprosy in this context being regarded as a form of punishment for the transgression of moral or ritual laws.

Thus the treatment of lepers has often involved an element of punishment and cruelty—in some cases even to the extent of burial alive or forfeiture of all rights, properties, and privileges. It is worth noting that none of these

extreme measures was ever lawful in England. In contrast, even as recently as 1937, fifty-nine patients in a leprosy settlement in northern China were lured to the edge of their village, shot, buried in quicklime, and their houses looted and burned—an expression of a basic biological impulse to destroy those members of the species who show physical, mental and/or spiritual divergence from orthodoxy—an impulse against which we must always guard.

LEPROSY IN EUROPE

From the time of Christ up to the 14th century leprosy spread steadily and increased in incidence throughout Europe. This was probably also paralleled on other continents, especially Asia and Africa. The Americas lagged behind until the 15th century saw the introduction of the disease from Europe by the Spanish, Portuguese, and, later still, Chinese traders who spread the infection widely through the South Seas.

Factors encouraging its spread in Europe were the rapid growth in population, increasing urbanisation and poverty, malnutrition and overcrowding, increasing trade, travel, and migration (for example, the Crusades).

By the 8th century various measures to combat the disease were in hand. Laws were passed aiming at the prevention or minimisation of contact (Figs. 2 and 3), based not on a true knowledge of the mode of transmission but more on an instinctive avoidance of contamination by evil influences, mysteriously conferred by the presence of the "unclean". Effective treatment, however, was not then available and had to wait until the mid 20th century. The Christian Churches have led the humane approach to leprosy work from the earliest times and have maintained this position to the present day. The foundation of the Order of St Lazarus in A.D. 370 was one of the earliest constructive moves to help leprosy sufferers, but unfortunately ignorance and fear were not easily overcome and the term "lazar house" soon acquired the unpleasant connotation which persists to this day.

Perhaps more remarkable than its rise was the even more rapid decline of leprosy in Europe which began in the 14th century; by the 17th century it had all but disappeared except from certain limited areas where it persists even to this day (parts of Spain, Italy, the Balkans, Russia, and Scandinavia).

The causes for the decline are much debated, since the implications are of great importance for eradication of the disease in other continents. The following hypotheses have been proposed:

1. An increase in natural group resistance resulting from long exposure to clinical and sub-clinical infection or to spontaneous causes.
2. The prompt eradication of the majority of sufferers, who themselves form the only reservoir of infection, by the various pandemics of plague in the Middle Ages.
3. The rise of tuberculosis, which has been claimed to displace leprosy by its faster rate of propagation; the same individuals being susceptible to both diseases and cross-resistance developing (Chaussinand).
4. The cumulative effects of the policy of segregation.
5. The improving standard of living.

Probably all these factors played some part.

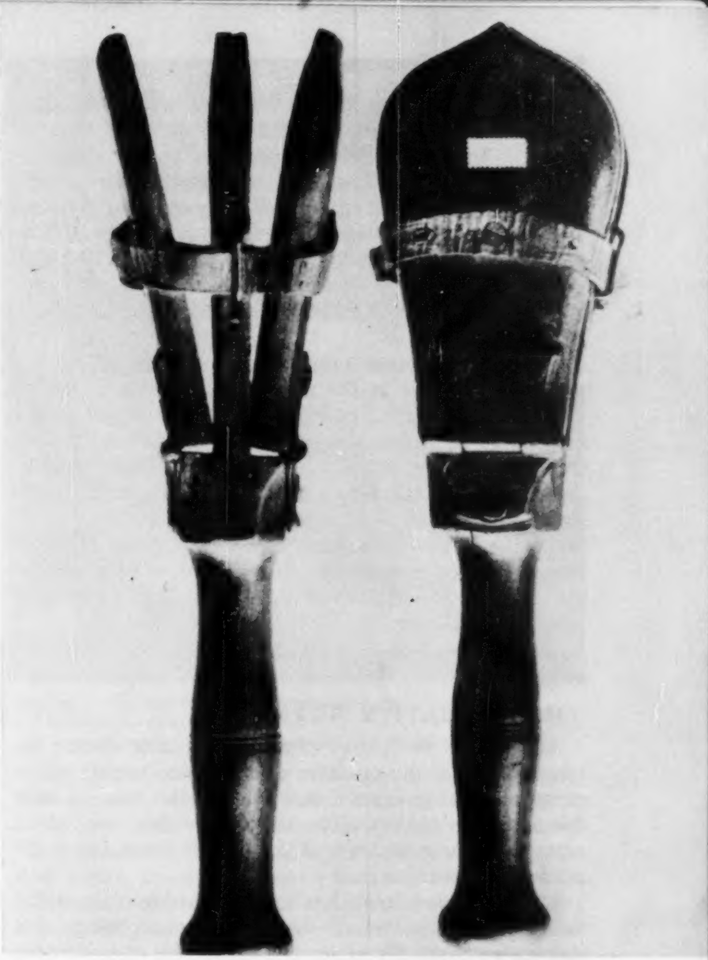
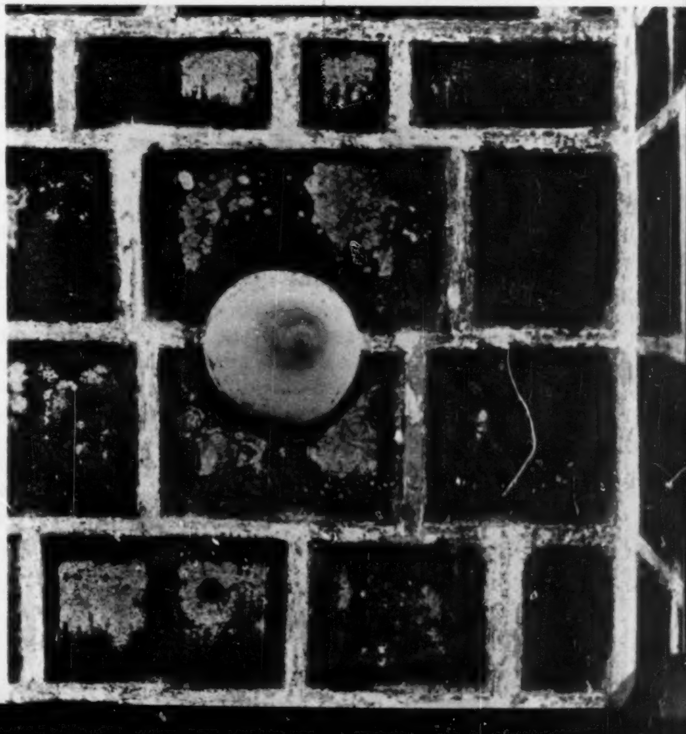


FIG. 2. (*Above*) Segregation: early methods of avoiding the "unclean" involved the obligation of patients to announce their coming by means of a bell or clapper.
(*Historical Museum, Schaffhausen*)

FIG. 3. (*Below*) Denied the privilege of mingling with the congregation, access to divine service was available for sufferers through the "leper squint".
(*Historical Museum, Schaffhausen*)



Interest in leprosy in the Western world thereafter remained somewhat in abeyance until the acquisition of colonial empires by various European states, which re-awakened European awareness to the important role played by leprosy throughout the rest of the world; for although Europe had been fortunate, the incidence of leprosy had continued to rise elsewhere; indeed, it is probable that only during the last quarter of a century has the world incidence of leprosy reached its zenith at around 10 to 15 million cases.

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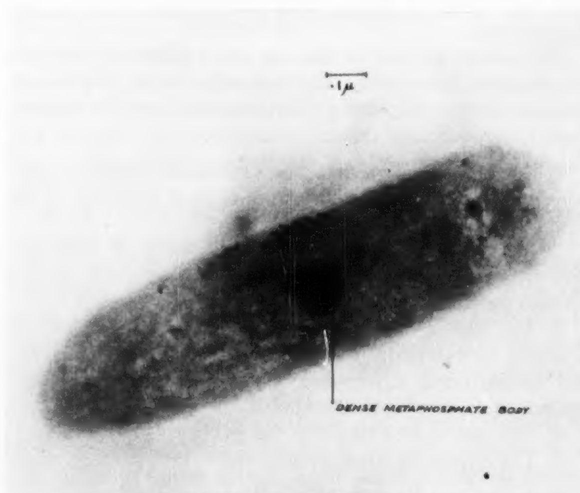
FIG. 5. A single cell of *M. leprae*, magnified ×20,000. The dark central opacity is not a nucleus but is probably concerned with metabolism and nutrition.
(By courtesy of Dr E. M. Brieger, Cambridge)



FIGS. 6 and 7. Lepromatous leprosy: nodular infiltration leading to the classical *facies leonitiasis*. Such lesions when ulcerated are a prolific source of bacteria for dissemination.

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CLINICAL DESCRIPTION OF THE DISEASE

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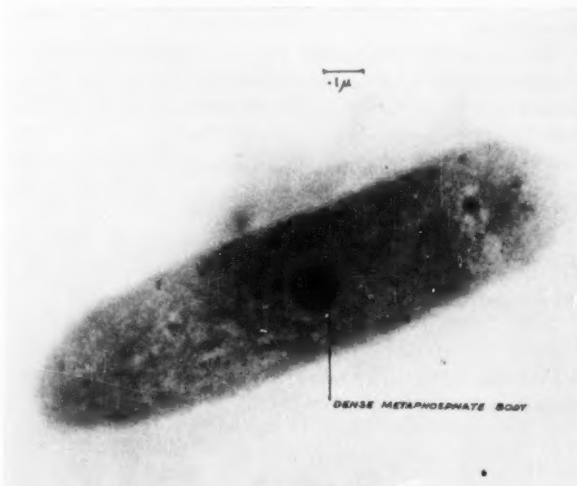

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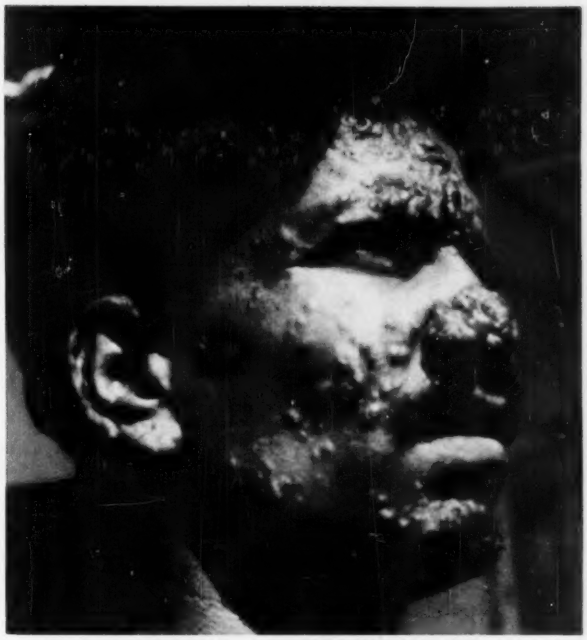

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FIG. 8. (*Top*) The end-result of ignorance and neglect. With modern knowledge such mutilation is avoidable, being the summation of successive unwitting injuries sustained due to the lack of sensation in the affected parts.

(By courtesy of Congo-Presse)

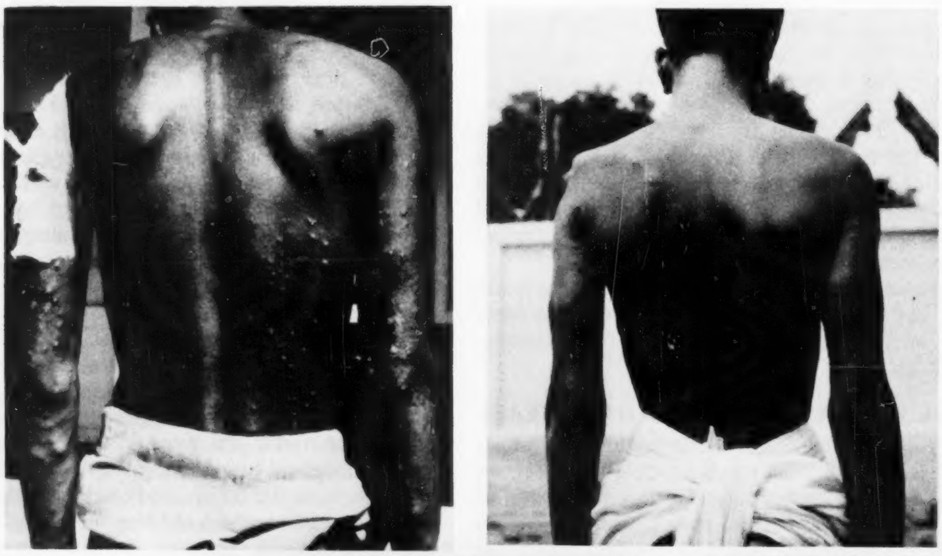


FIG. 9. (*Centre, left*) Untreated lepromatous leprosy. (*Right*) Progress after 9 months' sulphone therapy. Treatment must nevertheless be continued for some years.

(By courtesy of Dr R. G. Cochrane)

FIG. 10. (*Bottom*) Favourable response in an infant treated with DPT (CIBA 1906). There is no fear that this child will share the fate of the unfortunate case in Fig. 8.

(By courtesy of Dr A. T. Roy)

become widely disseminated throughout the tissues and the disease progresses more rapidly.

DEFORMITY AND MUTILATION

The affinity for nerve tissue is responsible for the altered sensitivity of the skin lesions especially manifest in the tuberculoid type. In advanced cases as the affection spreads centrally up the nerves and, especially in situations where the expanding cellular reaction in the nerve-sheath causes pressure effects on the sensitive conducting elements, there is loss of motor function as well.

The loss of pain sensation removes the most important self-defence mechanism of the tissues involved, and unless very great precautions are taken it is only a matter of time before unwitting and repeated injury and/or infection leads to ulceration, scarring and mutilation. Interference with motor nerve supply to the muscles leads to varying degrees of paralysis and resulting deformity (Figs. 1 and 8). These manifestations, which in the past contributed greatly to the loathsome appearance of the patient and the notoriety of the disease, can now be largely prevented by special care and physiotherapy, and in varying degrees corrected by orthopaedic surgery., This is another field of research in which leprosy offers a challenge and a stimulus to modern medical science.

LEPRA REACTIONS

During the course of the active disease a sudden reaction may occur in the patient's tissues which is probably a form of allergic response. A lepra reaction may be brought on by febrile intercurrent disease, by iodides, and most commonly nowadays by effective sulphone treatment. A reaction may last from days to weeks and may if prolonged lead to a deterioration in the patient's condition. On other occasions a patient may actually improve markedly after a reaction. In either case a reaction is usually unpleasant for the sufferer and often requires special treatment with cortisone or similar agents, and also the withdrawal of sulphone therapy.

HOW IS LEPROSY SPREAD?

It is now fairly well established that the only significant mode of propagation of leprosy is by prolonged and repeated skin-to-skin contact between a patient in an infective stage and a susceptible individual. There may be other possible modes of transmission such as inhaling infected droplets or particles from infectious patients—but, although the bacilli probably survive at least some little time outside the body, such indirect modes of spread are probably not important. The reasons why the basic mode of transmission was not realised earlier is the long "incubation" or latent phase lasting from two to twenty years and the fact that patients may excrete bacteria profusely long before any marked clinical evidence of the disease is manifest. In addition, some individuals appear to be resistant or even immune to infection.

It is small wonder then that the contagious nature of the

No longer a disease apart. Inspired by the new concept that leprosy is "no longer a disease apart", Burma, with an estimated 200,000 leprosy sufferers (over ten cases per thousand population—a prevalence rate twice that of India or Thailand and the highest in SE. Asia), in 1952 launched a nationwide anti-leprosy campaign with the help of the World Health Organisation. By mid June 1957, 42,000 cases had been registered and 33,500 were being treated with sulphone drugs. By the end of 1959, it is hoped to increase the number of cases under treatment to 50,000.

FIG. 11. The first objective of the campaign was the training of full-time "leprosy inspectors" to work in the highly infected rural districts. The first group of sixteen trainees, recruited from the ranks of public health inspectors with long experience in rural areas, followed a six-month course in all facets of leprosy control, including propaganda, case-finding, early diagnosis and treatment. They were assigned to their districts in early 1953.

FIG. 12. Dr Eduards, India, chief doctor at the Special Skin Disease Clinic attached to Rangoon General Hospital, examines a patient. Each patient has a card bearing drawings showing the infected parts of his skin. With this method progress can be carefully controlled.

(WHO photographs by Ernst Scheidegger)

disease was not realised in earlier times and that segregation, however, harsh or strict, was usually applied too late to be effective.

TREATMENT

Before 1943 there was no really effective treatment known. Chaulmoolgra oil (hydnocarpus oil) and its purified principles had long been used both locally and systemically by mouth and by injection, but all are virtually ineffective. It is also unpleasant treatment.

The first effective chemotherapeutic agent was diaminodiphenylsulphone (DDS) (Fig. A) and its derivatives (Fig. B). The reason why sulphones were tried in leprosy by Faget and his collaborators at the Carville Leprosarium in 1941 was that DDS had been shown to have activity against animal tuberculosis (although it subsequently turned out that sulphones have no clinical value in human tuberculosis) and because of the similarity between *M. leprae* and the related organism *M. tuberculosis.*

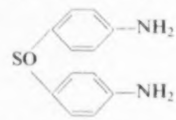
Since it is unfortunately not yet possible to test the action of potential agents against either growing cultures of isolated *M. leprae* or against artificially induced infection in animals, it is not practical to conduct a systematic search for potential compounds in the laboratory. The leprologist therefore keeps a watchful eye on advances in the chemotherapy of tuberculosis, and so far all the effective drugs in leprosy have come from efforts primarily directed against tuberculosis.

However, in addition to the misfortune of having no experimental equivalents for leprosy, it is already clear that activity against either human or experimental tuberculosis is no reliable guide to useful activity in leprosy. Thus the standard anti-tubercular remedies streptomycin, PAS (para-aminosalicylic acid), and INH (iso-nicotinylhydrazide) have all proved ineffective or too toxic for general use in leprosy. There is, however, some evidence that a combination of DDS and INH may be somewhat better than DDS alone. Other remedies which have been tried but found wanting in various respects are thiosemicarbazides, the vaccine of Sister Marie-Suzanne, and BCG vaccine.

All sulphones share certain disadvantages and side effects. Their action is believed to be bacteriostatic rather than bactericidal, it is slow and it is necessary to continue treatment almost indefinitely and certainly for some years. During this time the opportunities for side reactions to develop are great. Nausea, dermatitis, anaemia, and psychosis have been encountered. Reactions are commonest and more serious in debilitated and anaemic patients. In spite of their disadvantages, the sulphones alone, if made available to all who are able to benefit, would probably in the long run turn the biological balance between mankind and the bacillus in favour of the former (Figs 9 and 10). Such a matter cannot, however, be left to chance, and new and better remedies are constantly being sought.

The most significant recent advance in this field is the discovery of a disubstituted diphenylthiourea (Fig A). On the basis of over three years' clinical trial by Davey and his collaborators in Nigeria and confirmed by others elsewhere, this is probably the most useful drug available so far for the treatment of leprosy. Like other leprosy remedies it was discovered as part of a programme of research on drugs

DDS (4, 4′-diaminodiphenylsulphone)



DPT (4-butoxy-4′-dimethylaminodiphenylthiourea)

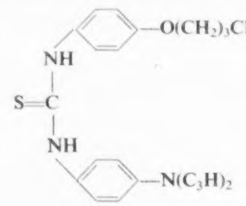
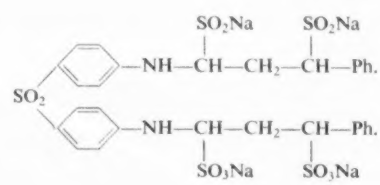
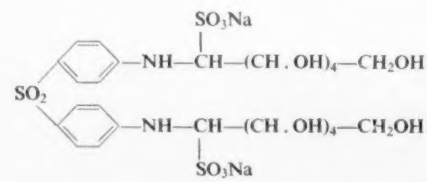


FIG. A. Diaminodiphenylsulphone.

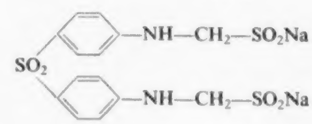
Solapsone



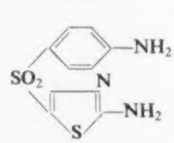
Glucosulphone



Sulphoxone



Thiazolsulphone



Thiosemicarbazone

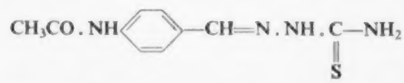


FIG. B. Sulphone derivatives.

effective in tuberculosis, against which disease it is also active *in vitro,* in the experimental animal and to a lesser degree in man. In the opinion of those who have used it clinically in leprosy it is more active than DDS and has the advantages of universally good tolerability and the fact that lepra reactions when they occur are much less severe and do not necessitate interruption of treatment. It may also be safely combined with other leprosy drugs.

An important consequence of the discovery of this drug

is that it has stimulated new research on the metabolism of the drug using radioactive labelling techniques which could lead to the identification of more active derivatives formed in the body or suggest advantageous modifications which may be made in the laboratory, thus providing a rational approach to further new drugs without the necessity for a laboratory screening method dependent on animal infection or culture technique.

Other new drugs are certain to follow. At least three of importance developed in different laboratories are already undergoing field trials, of which one, at present being tested in Indonesia, was also originally discovered as a result of the same programme of research on thioureas which led to the introduction of CIBA in 1906. When it is realised that from three to six years are required to establish the value and safety of a new drug in such a chronic disease as leprosy no very rapid advances can be expected.

CONTROL AND PREVENTION

Now that effective remedies are available for the treatment of leprosy, the greatest problem remains to bring the drug to the patient and ensure its correct administration.

Activities against leprosy are already organised on an international scale, and in November of this year the Seventh International Congress of Leprosy took place in Tokyo, at which specialists in all branches of leprosy met to discuss all aspects of the problem.

There is a growing awareness in many quarters that leprosy can and ought to be eradicated. Using the new diphenylthiourea, experiments are already being organised in collaboration with the local health authorities, in two selected and limited areas of population to demonstrate the practical possibilities of such a scheme for the eradication of the disease. Obviously a world-wide programme is only within the resources of the World Health Organisation and its member nations. Thus, with the increasing response of scientists and administrators to the challenge and stimulus of leprosy, the age-old curtain of prejudice, ignorance, and fear is slowly lifting.

READING LIST

Brieger, E. M., and Glauert, A. M., "The Electron Microscopy of the Leprosy Bacillus", *Tubercle*, 1956, vol. 37, p. 195.

Davey, T. F., "The Treatment of Leprosy with Diphenyl Thiourea Compound Su 1906 (DPT). A Report on Expanded Trials in Nigeria", *Leprosy Rev.*, 1958, vol. 29, p. 25.

Chaussinand, R., "La Lèpre", Paris, Expansion Scientifique Française, 1950.

Lowe, J., "Comments on the History of Leprosy", *Indian Med. Gaz.*, 1942, vol. 33, p. 680.

Macarthur, W. P., "Medieval Leprosy in the British Isles", *J. Roy. Army Med. Corps*, 1925, vol. 45, p. 412.

Muir, E., "Manual of Leprosy", Edinburgh, Livingstone, 1948.

Ryrie, G. A., "The Psychology of Leprosy", *Leprosy Rev.*, 1951, vol. 22, p. 13.

Weymouth, A., "Through the Leper Squint", London, Selwyn & Blount, 1938.

FIG. 13. As more and more cases are discovered and treated and the reservoir of infection is reduced, children now growing up will be less and less liable to contract leprosy. Even for these young leprosy patients, caught in an early stage of the disease, there is strong hope of a complete cure for many of them. Burma looks forward to the day when this age-old scourge will be conquered once and for all.

(WHO photograph by Ernst Scheidegger)

THE PETROLEUM INDUSTRY LOOKS AHEAD—

FORTY YEARS ON

JOHN A. ORIEL, C.B.E., M.C., M.A., B.Sc., F.R.I.C., M.I.Chem.E.

The Shell Petroleum Company, London

Crystal gazing is a particularly unrewarding occupation in the oil industry, where technical development tends to overtake speculation with disconcerting speed. However, "time spent on reconnaissance is seldom wasted", and a brief discussion of some of the questions likely to exercise forward-looking sections of the industry during the rest of this century may be useful. It is convenient to consider these matters under three headings: Scientific Research; Organisational Research; The Human Element.

SCIENTIFIC RESEARCH

The petroleum industry is mainly concerned with: (*a*) discovering, collecting and transporting crude petroleum; (*b*) making marketable products from the crude; (*c*) selling the products; this operation is based on an expert knowledge of their performance.

All these activities are supported by research and this will remain the case for the rest of the century. Indeed, the proportion of the industry's income devoted to research is likely to rise. For example, speciality products (such as super petrols, lubricants, and chemicals) will grow in importance to the industry as the somewhat indiscriminate burning of petroleum for large-scale energy production is reduced by the development of nuclear power. The research levy in the speciality field is ten or more times that for fuel oils on the basis of gross sales returns. It is, therefore, reasonable to expect that at least 3% of gross turnover will be spent on research by the end of the century as compared with about 0·5% at present. Three per cent is already roughly the figure applying to the sector of the business dealing with chemicals from petroleum.

The overriding need in oil exploration is to increase the probability of success. Research in this field is likely to be concerned with development of physical methods of search, the recent simplification of seismic survey by the development of weight-dropping methods is a relatively crude case in point. But the bulk of future research concerned with exploration for new crude oil reservoirs is likely to deal with facilitating surveys under the sea. Relatively this is an unexplored region already yielding fewer dry holes than searches on land. Similarly, production research will largely relate to techniques for off-shore drilling, while the search for more economical drilling methods is bound to continue, perhaps following on the development of the turbo-drill pioneered by the Russians. Another fruitful region is likely to be the increase of yield from producing fields. Extraction is now normally less than 50%, and the potential yield on investment in research on this subject is obviously great. Progress is already steady, if slow, and the development of such methods as steam injection show interesting promise. However, as petroleum becomes a source of more sophisticated products at the expense of bulk fuel offtakes, it will be increasingly attractive to work shales and tar sands, particularly where such deposits lie on or near the earth's surface. Research is still likely to be dealing with tar sands at the end of the century. Similarly, the natural gas (largely methane), associated in such enormous quantities with liquid crude reservoirs, will become increasingly precious and a large research effort devoted to its utilisation can be foreseen. Some of this research is likely to be related to handling and shipping the liquefied refrigerated gas from isolated producing areas where pipe-line distribution is ruled out. Moreover, should the shipment of liquefied and refrigerated gases reach large proportions, inevitably attempts will be made to utilise the "cold" which is being transferred. For example, in evaporating the gases at the reception end, it may be desirable to build large liquid-air plants to take advantage of refrigeration effects, and so develop subsidiary "tonnage oxygen" industries.

In the manufacturing field the use of biochemical processes may expand. Cases already exist in which refinery effluents are bacteriologically treated to facilitate disposal: wider research and application in the biochemical field may just possibly extend the field of application. Research on manufacturing will certainly be more and more dominated by the aim to produce chemicals from petroleum solvents, plastics, elastomers, and perhaps even foodstuffs. Laboratory work now indicates that a whole new hydrocarbon chemistry may be based on atomic radiation effects. Whether it will prove possible to work out a technology of radiation-inspired reactions which can take its place alongside the "normal" technologies of thermal and catalytic effects, is an interesting speculation. Polymerisation of molecules such as ethylene can readily be initiated by high-energy radiation as an alternative to thermal, catalytic or photochemical initiation. This technique provides a convenient way of "tailoring" polymer molecules for specific applications. For example, straight-chain polyethylene molecules may be cross-linked to increase the rigidity of the polymer. Nuclear energy plant could well be situated near a refinery to make the best overall use of the fuel and raw material resources of both installations.

PRODUCTS RESEARCH

Population and other pressures are bound to maintain the trend towards research in aid of world agriculture. Research will surely return to the endeavour to develop a really cheap but effective soil-conditioner to supplement the rising fertiliser production and compensate for the diminishing availability of animal and vegetable refuse.

Regarding fuels, many people believe that the small prime mover (such as the car, tractor and motor-scooter) will continue to use petroleum fuels well beyond the end of the century. Some have proposed that, if and when natural petroleum becomes unobtainable, hydrocarbon fuels for

small prime movers will be synthesised from materials such as chalk or organic wastes, using the abundant electrical power predicted as forthcoming from nuclear sources. It is difficult at the moment to visualise any more convenient or efficient way of storing electrical energy in a form which can be utilised by the light vehicle.

For vehicles below, say, 50 h.p. it seems probable that the high compression ratio petrol engine will remain the most attractive unit. This engine will require fuels well over the 100-octane mark, but it is safe to assume that, if the reciprocating petrol engine survives in this way, the ideal fuel will have been finalised long before the end of the century, and research on this topic will not be in progress then. This situation already applies to aviation petrol for the reciprocating aero engine.

The heavier type of road vehicle, including powerful cars, at the end of the century may possibly be powered by a gas turbine, diesel engine or hybrid such as the free-piston engine. These will be using a petroleum fuel, but since such engines are already much less sensitive than the petrol engine to the chemical composition of the fuel, real research as distinct from trouble-shooting investigations on these fuels may well not be required beyond the next twenty to twenty-five years.

It is not out of the bounds of possibility, of course, that by the end of the century the motor-car will be seen as a complete anachronism anyway. To use a ton-weight vehicle to move a hundredweight and a half of man is not very efficient. Population and other pressures referred to above may lead to the development of minimum weight vehicles—perhaps the ubiquitous scooters are its precursors. A logical extension would then be the small personal helicopter of 50 to 60 lb. which would have the added advantage of cutting down the enormous capital requirements of road systems.

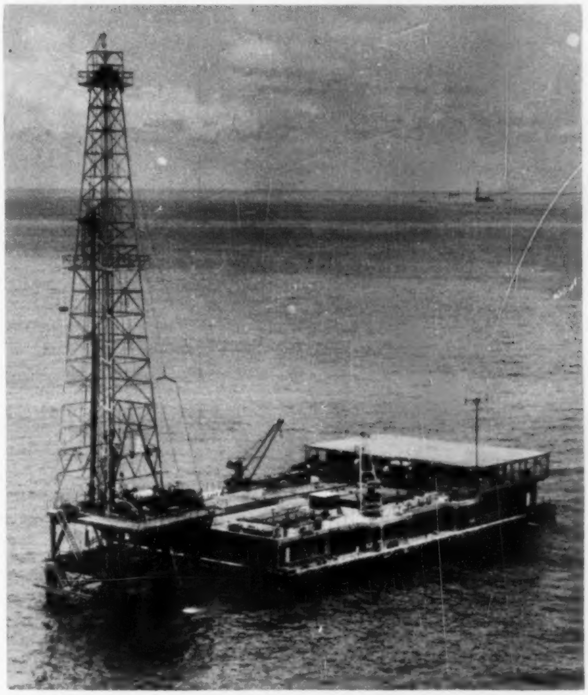


FIG. 2. The Shell drilling barge, "G.P.4", on Lake Maracaibo, Venezuela. The barge is used in conjunction with a permanent drilling platform erected at each well site, and is in effect a floating power station and supply vessel. Note landing platform for the helicopters that service the well site.

(All photographs by courtesy of Shell)

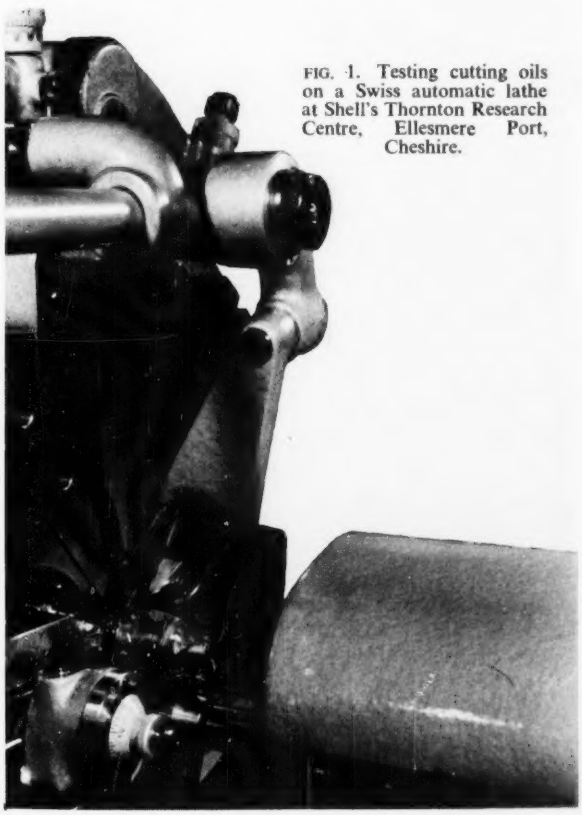


FIG. 1. Testing cutting oils on a Swiss automatic lathe at Shell's Thornton Research Centre, Ellesmere Port, Cheshire.

WONDERFUL FUELS

Research on aviation fuels, however, is a very different case. For military and a limited sector of civil applications, rocket fuels will be developed rapidly during the next half-century. Rockets must carry their own oxidising material to react with the fuel, and research on both partners will remain active. It seems unlikely that petroleum will provide the source of the ultimate propellent, which may conceivably consist of substances such as liquefied hydrogen and fluorine available through electrolytic processes. Research may nevertheless develop on such propellents within the petroleum industry which may decide to enter parts of the fuel business outside the confines of petroleum raw materials. This sort of development is already afoot regarding lubrication practice.

Conventional gas-turbine engines will still be operating in aviation at the turn of the century, and research on unconventional fuels for these engines will persist. The aim will be primarily to produce a "low drag" fuel, that is one with improved calorific value per unit volume. At the same time, a reasonable calorific value per unit weight must be achieved and, unfortunately, the only materials

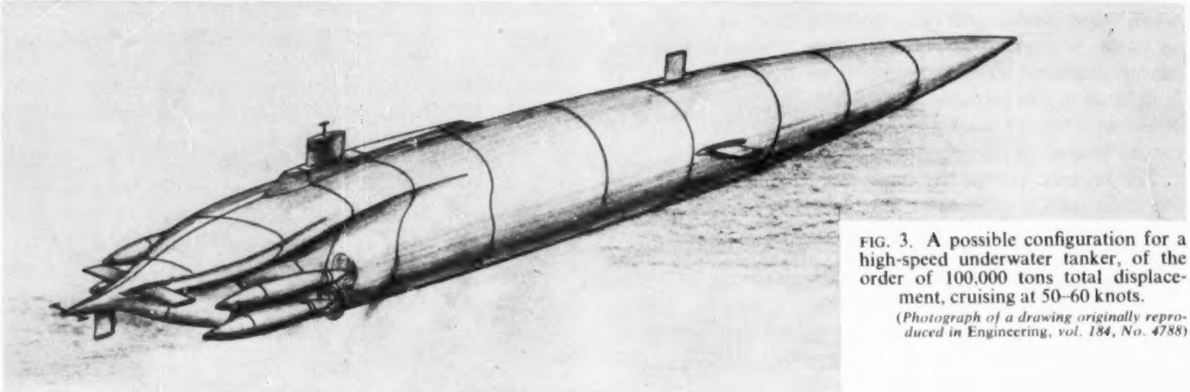


FIG. 3. A possible configuration for a high-speed underwater tanker, of the order of 100,000 tons total displacement, cruising at 50–60 knots.
(Photograph of a drawing originally reproduced in Engineering, *vol. 184, No. 4788)*

which are then outstanding performers, relative to hydrocarbons, are solids such as beryllium and boron. It does not seem unrealistic to foresee research on fluidising solids such as these to make practicable their use in aircraft capable of completing the London to New York crossing in about one hour.

If techniques are developed to handle finely divided solids in this sort of way, they could lead to further research on using, in fuels for airborne vehicles, the energy bonus available by predissociating fuel molecules. The objective would be to trap radicals, such as atomic hydrogen, in a solids in this sort of way, they could lead to further research calorific value of the system itself, together with the heat of recombination of the built-in free radicals.

For the propulsion of railway trains and ships, petroleum fuels will have been largely superseded by electrical power from atomic energy and direct nuclear propulsion units respectively. A main oil tanker fleet may consist of nuclear submarine ships of about 100,000 tons, travelling about 300 ft. below the ocean surface. Research on this type of transportation is likely to concentrate on subjects such as navigation. Regarding marine propulsion in general, however, there is an interesting prospect of research based on an investigation recently started by Prof. Thring of the University of Sheffield. This concerns the idea of generating an electric current by burning a fuel but avoiding the intermediary of an engine such as the diesel or gas or steam turbine. Prof. Thring is aiming to show that the ions produced when a fuel is burnt can be secured and accelerated in sufficient measure to induce a current when the exhaust gas stream travels at high velocity through a magnetic field. This current can be tapped by electrodes in the stream. While the overall efficiency of this process may not be spectacularly high, the promise of a very compact generating system invites applicational research. Perhaps this sort of scheme would even be attractive as an alternative to the gas turbine for propelling road vehicles.

LUBRICATION AS SUCH

Lubrication research leads a petroleum organisation into studies of almost every kind of engineering process and product in which surfaces move over each other. These range from metal-forming processes to the operation of finished power plants and related components. A similar breadth of research studies will always be necessary and, as already implied, will involve petroleum companies in selling lubrication as such rather than merely those lubricants which can be based on petroleum starting materials. This will apply especially in the high-temperature lubrication field, already becoming extremely important. Lubrication by liquid metals, such as sodium, may develop. Liquid lubricants have the great advantage of facilitating heat exchange as well as controlling friction and wear. Nevertheless, solids, such as graphite, are already accepted for applications in which a liquid of suitable properties cannot yet be found. Perhaps the field for solid lubricants may be extended through an approach already referred to

FIG. 4. Gravimetric exploration; the waterproof steel housing containing the remote control gravity meter about to be lowered from the stern of the launch *Shellex III* in order to take readings.

in considering fuels, that is, fluidisation of finely divided refractory materials.

The development of nuclear power has not only given added impetus to the search for new lubricants and heat exchange liquids to withstand high temperatures but has also called for radiation resistance in these materials. For example, petroleum fractions are being considered as combined coolants and moderators for atomic piles instead of synthetic hydrocarbons such as polyphenyls which are more expensive and inconvenient because they are solid at normal temperatures. An intensification of research to produce oils and greases more resistant to cracking and subsequent polymerisation is therefore likely.

Drawing largely from a talk given by Lord Baillieu, about the commercial utilisation of research results, the following can still be stressed as summing up the research objectives of a 21st-century industry selling a range of products:

(1) Increasing the production of a material in demand; (2) reducing the cost of a material in demand without sacrificing quality; (3) substituting a cheaper material for one in demand without sacrificing performance; (4) improving quality without extra cost; (5) introducing a new product capable of saving the time, money, effort of the purchaser.

ORGANISATIONAL RESEARCH

The systems underlying the manufacturing processes themselves cannot escape scientific examination in the period under contemplation, by the methods of operational research.* Two of the main routes of advance appear to be the development of product quality adjustment by automatic control, and the integration of more than one plant into an automatic system. The two concepts are, in fact, closely linked in petroleum refining, as a refinery is not only an integrated unit but also a complex of interrelated plants and processes, the relationship of which may be altered all along the line by changes in any one of them. The relatively recent development, therefore, of linking the results of mass spectrography analysis via a computer to the control of a refinery complex involves both concepts.

This in turn leads to consideration of the refinery in its own setting. It is a complex unit within a complex of refineries, themselves standing in a highly complex relationship to all their possible sources of crude oils of various characteristics and values. When it is recollected the world demand for oil (outside the Soviet bloc) has doubled within the last decade, and is continually altering its distribution between many manufactured oil products, and when it is further recalled that the oil industry must expect demand to double again by the early 1970's, it becomes evident that the task of the scientist may well extend beyond consideration of isolated refinery problems on their own merits. The reduction to quantitative terms of the factors involved in complex decisions is a function of the scientific method that is being increasingly called upon, sometimes under the name of operational research, sometimes under other descriptions.

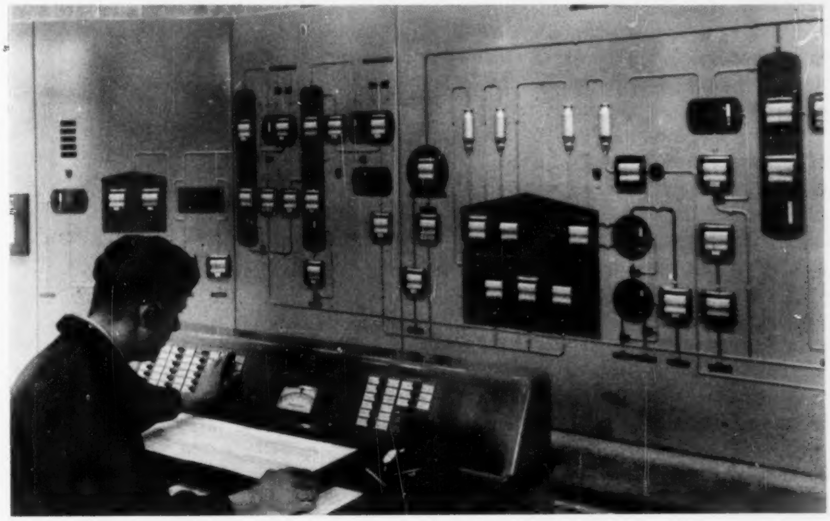


FIG. 5. The platformer unit's graphic panel at Shell's Stanlow Refinery near Ellesmere Port, Cheshire; the panel is fitted with micro instruments.

The techniques of operational research are frequently appropriate in the oil industry—the regard for common structures (and hence common laws) in apparently unrelated series of operations; the mobilisation of different scientific disciplines in a given project. The method of linear programming, for example, is much used by operational research workers who find common ground between operations in the electricity generating, air transport, food processsing and metallurgical industries as well as in the oil industry. Linear programming has been described as a way of "charting the cheapest path through a maze of which the alleys are different conditions". Clearly such a technique is appropriate for calculating optimum settings of a refinery, given inputs and outputs. But it is of much wider application, and a recent survey before the Institute of Management Sciences in the U.S.A. showed that it now covers work on exploration, production, refining and distribution. In each case, the function is to determine the best possible employment of resources given certain conditions, and in circumstances where hundreds or thousands

* The most usual definition of O.R. describes it as "The application of the scientific method to provide executives with a quantitative basis for decisions regarding operations under their control." (Goodeve).

of choices are possible. An important extension of the technique is that it is further possible to give quite a lot of information about the "next best" series of possibilities within a short distance of the best. This may be of particular value where operational research techniques are used for studying data in connexion with investment selection.

Linear programming is a good example of operational research technique in the oil industry, but not, of course, the only one. In a recent paper, "Operational Research in Canada", Patrick J. Robinson of Imperial Oil Ltd lists fourteen major research methods in use, and quotes an interesting list of eleven practical cases of their employment in his own firm.

Many of the techniques are highly mathematical. Programming a refinery may involve as many as 200 linear equations, the solution of which can only be obtained in reasonable time by electronic computer. It has recently been announced that The Shell Petroleum Company, which has been using one at the Royal Dutch/Shell Laboratory in Amsterdam for the past three years, has placed one on order for its London office, where it will be in operation early next year. It is to be used "for special calculations covering commercial aspects of all activities from exploration to marketing".

The further development of the use of the scientific method as an aid to management decision offers some interesting possibilities. It seems likely that operational research, or something like it, will be accepted into the canon of management practice much as budgetary planning and control have been accepted in the not so very distant past. In that event one can envisage particular problems being tackled by teams of specialists from various departments. These specialists would co-opt an operational research analyst from some central pool to aid in formulating the problem, in gathering the data and in analysing it in the light of the collective knowledge of the team. Nor is it impossible that this scientific scrutiny will come to be extended to such other managerial tools as accountancy and man management. The application to management of the science of cybernetics is likely to be investigated with increasing intensity in the near future. (*See also p. 518*)

Whether these particular developments occur or not, it seems to be beyond doubt that the impact of scientific methods on managerial decision "has increased, is increasing, and ought to continue".

THE HUMAN ELEMENT

It is widely recognised that the development of automatic control of individual plants and its probable systematic extension raises human problems of the most far-reaching importance. Some of them have been fruitfully discussed in a report by the Department of Scientific and Industrial Research. Does the worker become a mere slave to the machine? A mindless presser of knobs at the flash of a light? There is no doubt in the mind of the present author that this is not a real danger. In fact, a fair degree of conceptual thought is required in the panel-man; for example, on a "Platformer" not only must he understand what each instrument signifies, but also their inter-relation. He has, moreover, to judge whether a change in a recording really reflects conditions on the plant, or is due to a fault in the instrument. And the panel-man's job is quite typical of what is required of a worker on an automated plant today. One of the lessons that this conclusion holds is that more men of technical grasp and vision are likely to be required on such plants rather than less. It is part of an enlightened staff policy, therefore, to encourage and assist employees to obtain technical qualifications.

More generally, there can be no doubt that the developments under discussion will call for changes in the requirements for staff. It is difficult, in considering world-wide staff, to look ahead for forty years in a short article of this type. Conditions vary so much from the developed countries to the underdeveloped countries that to attempt to do anything of the sort is in fact impossible. The underdeveloped countries will need, in the next forty years, establishments for training men in the crafts and as technicians. There must be a great deal of emphasis on this, because the present tendency is to rush in with schools for higher education without arranging for that very necessary layer of technicians and craftsmen.

In the fully developed countries, however, one might

FIG. 6. A jungle survey school has been formed to train regional staff and Dyaks in rudimentary survey work. These men, when trained, are able to assist surveyors, geologists, and seismologists in their exploration work.

hazard a few guesses. We can consider the growth in the next forty years of the type of senior grade who will be required in industry. Industry is becoming every day more scientific and technical, and among the very large number of those in the intermediate grade of staff there will unquestionably be required more and more technologists and technicians. This trend will extend, of course, as much to the office as to the factory, and with the introduction of electronic computation, one can expect marked reductions in the employment of unskilled clerical labour, as the technician takes its place. However, one would not necessarily expect it to be the expert who will eventually direct affairs, but rather the man who can synthesise the ideas and views of the various interests, technical and non-technical, involved. He must be the man who, as today, can see the real objective clearly and not, as so often happens, allow himself to be taken up with side issues. He will purposely maintain an overall general knowledge and be prepared to let subordinates get on with the detail.

SCIENCE AND WORLD AFFAIRS

These, of course, are not new qualities required in leadership, but the question arises whether these qualities are to be found in future among our scientists and technologists or among those versed in the Humanities. It is the writer's opinion that a blend of these will be required. The expert is seldom the right man to dictate strategy; he must be left with the tactics—and yet the strategist will have to know, and know well, not only the capabilities of science and technology but also their limitations. He must therefore have a broad outlook, combined with a general knowledge of science and technology, and sufficient imagination to be able to look forward ten to fifteen years into the possibilities of technology. This imagination is possibly somewhat different in type from that required by the research scientist, but it is of the utmost importance for development of industry.

Science and scientific achievement are often dealt with as things apart and as though they had had no repercussions on society, and society had no effect on them. This is far from being the truth. Perhaps up till 1914, science, while contributing to social development, was not of great importance in developing history. But from 1914 onwards, and increasingly of late years, science has in fact become a major factor in world affairs.

There is no industry now in which science does not play its part, and we should be quite clear that when we speak of scientific development we are referring to the application of science. Scientific hypotheses and theories are advanced, used and discarded, but their application goes on accumulating. At the same time, science is a way of life and a way of approach to problems which must of necessity affect all sides of modern life. The application of science and the development of material improvements following on scientific thought have been growing steadily since the scientific revolution of the 17th century, and the problems of the day and scientific development have constantly been in interaction one with the other. For example, it was the urgent need for means of navigation in the 17th and 18th centuries that spurred on a great deal of work which finally led to the production of the exact chronometer. This is not an isolated example and such instances could be multiplied right down to 1914.

We take 1914 as a datum line because it marked the beginning of two world wars, both of which have been responsible for the speeding-up of scientific development and the application of science to a much greater extent than would have been the case had there been no war. Had it not been for these two wars, the development would have proceeded at a pace commensurate with human development, human understanding and assimilation, but the forcing of the pace has left a vacuum. This obvious gap between material gain due to scientific application and the failure to keep pace morally, socially and politically has caused men to sit up and take notice, and perhaps today more than ever people are wondering where the misuse of science is leading us. On the other hand, we see that the intelligent application of science has shortened man's working hours; has lightened his labours; has substituted plenty for scarcity and has decreased death rates but not birth rates. And this must continue, as men will continue to probe the mysteries of Nature and the applied scientist will always wish to use those mysteries which the pure scientist discloses.

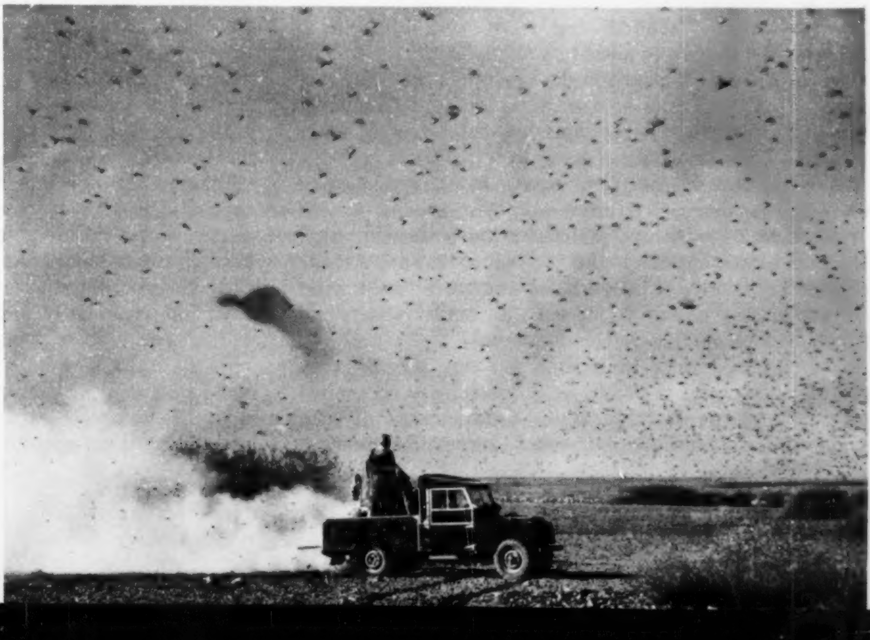


FIG. 7. Two insecticidal dusts, Aldrin and Dieldrin, being used in anti-locust operations in North Africa.

SOVIET CYBERNETICS

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Burden Neurological Institute, Bristol

In the recent article by Dr L. Sukharebsky, republished in English in an abridged version in *Soviet News*, Thursday, July 10, 1958, some interesting light is thrown on the Soviet views of the new discipline of Cybernetics. Derived from the Greek word meaning steersmanship, Cybernetics is usually defined as the science of control and communication in machines, man, and society. The inference of this way of thinking is seen in fields as wide apart as the study of animal behaviour, investigation of brain disease, and the development of automation in industry. Until fairly recently the Russian workers attempted to keep these various domains of human interest separate, but they have now joined with the Western world in seeking for ideas which can increase progress in all fields by formation of multi-disciplinary teams of research as well as by the discovery of new laws and principles which transcend the boundaries between living and physical systems.

At the tactical level there is no discrimination between workers all over the world; new methods of investigation and manufacture are constantly being discovered and, as we all begin to realise, the limits of automation are not set by technical ingenuity but by economic necessity.

There seems to be one point of difference between the Soviet view and that held by some, though not all, Western Cyberneticians. From the experiences of the last generation, most of us are learning to refrain from negative predictions. Not very long ago quite eminent scientists were able to prove to their own satisfaction that man could never fly, that atomic energy could never be released, and that space travel was impossible. We now accept the possibility and even the reality of all these, but in the field of Cybernetics conjecture is more difficult. There is a good deal of argument about whether electronic computing machines can ever equal or surpass the capacity of human brains. Such instruments have, of course, often been referred to as "electronic brains", but this designation is really frivolous since existing computing engines have not been designed as cerebral surrogates but merely as extensions to human faculties—not really very different in character from a pair of pliers or a microscope.

In his article, Dr Sukharebsky ventures a negative prediction that "no matter how much we increase the number of tubes in a Cybernetic machine, we shall never get either a human brain or anything equal to it". This is perfectly true if we restrict ourselves merely to extrapolation of existing machinery, but there are many people in the Western world (and indeed some in the Soviet countries) who see a little farther round the corner and are already considering the design of machines which will have exactly the exploratory powers which our own brains possess and which mere computing engines are denied.

Computing devices in general do not actively seek problems but wait patiently until carefully programmed computations are fed into them. Certain parts of such machines have what one may call Cybernetic components or systems, particularly in so far as they are capable of self-correction and the avoidance of paradoxes and insoluble dilemmas. But there is no reason why machines should not possess exploratory tendencies. Such instruments could explore the world, within range of their receptor system, form fresh associations, acquire "hunches", test them by experiment, acquire new information to correct and explain the hunches and build up a reasonable tentative philosophy of the world as revealed to them by their sensing devices.

It is an interesting technical point that the limitations definable at present reside mainly in these sensing devices. As I have already mentioned, the conventional electronic computor is strictly limited in this respect. It must be provided with information, coded in a very special way in the form of a programme devised and written by an expert mathematician. The input to the machine is therefore filtered by the senses and brain of the human programmer.

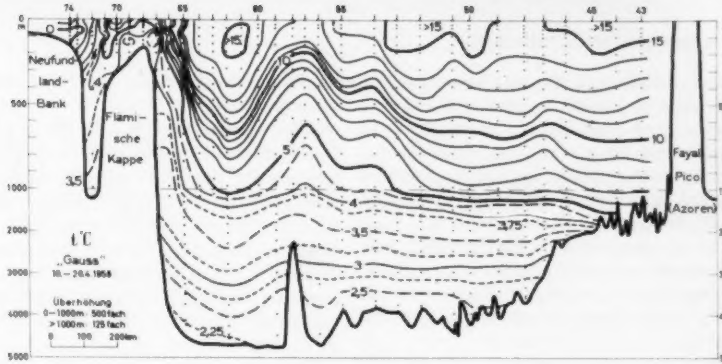
In the application of machines to industry, the development usually referred to as automation, also, the limitations are usually in the sensing devices—the ways in which the automatic machinery perceives the environment it is designed to control. The difficulty here is that the computing machines which have attracted most attention are designed exclusively for the solution of arithmetical and logical problems, whereas as far as we know the human nervous system is capable of far more than this. For us, arithmetic and logic are only special cases of the more general field of perception and cognition. If we have to, we can operate as binary machines, that is like Alice when challenged by the White Queen—'Add one and one and one and one and one . . ." but our tendency is rather to operate on what is called an analogue basis. We build up in our brains working electro-chemical models of the outside world and these we manipulate as a rehearsal for action. The setting-up of analogue models is by no means beyond the capacity of artificial devices, and, although this has been achieved only in miniature at the present time, we can see no fundamental objection to extending this process so as to mimic very much more closely the operation of living systems so that even our more romantic and subtle functions can be extended and perhaps refined with the collaboration of our mechanical slaves.

Whether this development is necessary or desirable must depend upon the economic and social structure of the world we are building for tomorrow. Serious decisions must be made about the place of human beings in the Universe, since mechanical aids to real thinking and feeling must influence the way in which we control our outside world. The deep and passionate hope of all Cybernetic workers in the Western countries is that experiments with really brain-like machines will reveal unifying factors and natural laws which will make world-wide co-operation of human beings not only more necessary but more attractive.

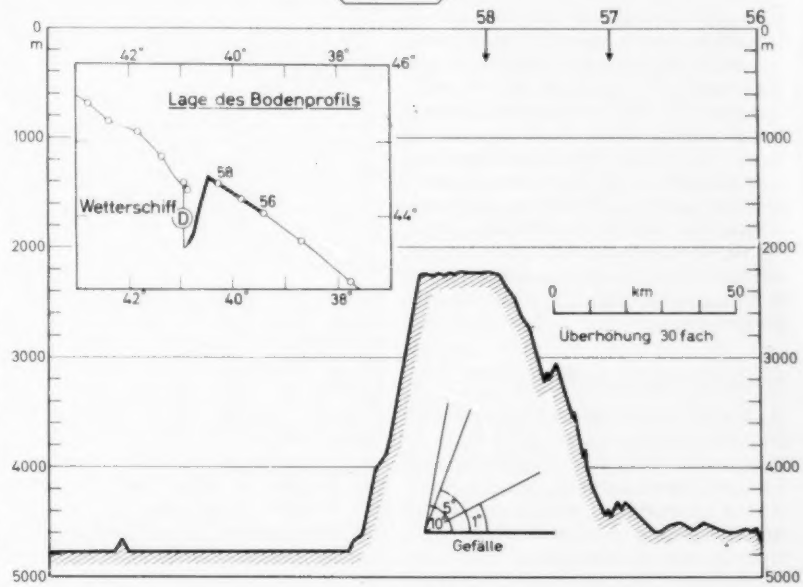
THE INTERNATIONAL GEOPHYSICAL YEAR

MONTH BY MONTH

Compiled by Angela Croome



ANNÉE GÉOPHYSIQUE INTERNATIONALE
1957 1958
INTERNATIONAL GEOPHYSICAL YEAR



FIGS. 1 and 2.

Mountains and Currents in the Atlantic

Twenty research vessels from nine different countries which border the Atlantic Ocean have been occupied during the IGY with the vast "polar front survey", perhaps the largest detailed investigation of what happens between the ocean surface and the sea-bed that has ever taken place. The work, initiated by the International Council for the Exploration of the Sea, Copenhagen, is not expected to be complete until the IGY is over. The main object of the studies has been to map exhaustively the profile of water meeting and mixing in the Atlantic, the main volumes of circulating water being that of the warm Gulf Stream flowing principally northwards, and that of the cold Arctic waters flowing in a generally southerly direction.

The results of the German expedition in the Deutsches Hydrographisches Institut of Hamburg's vessel *Gauss* are shown here, during this year's spring cruise for the survey. The responsible scientists were Dr J. Joseph and Prof. G. Dietrich. The first figure (1) shows conditions along the edge of the Gulf Stream on a line between Newfoundland and the Azores. The contour lines represent the distribution of water temperatures along this section, in degrees Centigrade. The temperature stands at about 3·5°C at 2000 m. deep all the way across the Atlantic save over the Flemish Cap, where it is only 4°C at a mere 200 m. beneath the surface. Where the cold water of the Labrador Current sweeps down from the Arctic between Labrador and Greenland. In contrast, three cores of warm water near the surface with temperatures of 15°C or greater were found, which in all probability belong to the three branches of the Gulf Stream which splits up near this area.

In addition, this cruise of the *Gauss* located by echo-sounder a previously uncharted "sea-mount" on the ocean bottom at about 45·5° N, 40·5° W (see Fig. 2). This mount rises rather suddenly from the sea-floor at about 4800 m. deep to a height of 2100 m. deep. It is also seen on another scale in Fig. 1.

New World Magnetic Survey

There has been a favourable reception from IGY stations to the proposal to carry out a new magnetic survey as soon as conditions are suitable. This will probably be in about five years' time when the minimum in the eleven-year sunspot cycle may be reached, and magnetic conditions are at their most stable. The original suggestion was to carry out the survey at once, but this would defeat its own object; we are currently in the midst of the most active sunspot maximum ever recorded and this is reflected in the geomagnetic record.

In the meantime a world magnetic survey committee is being set up by IAGA, the International Association for Geomagnetism and Aeronomy.

It will be thirty years next year since the last world-wide magnetic survey was taken. It can safely be concluded that even such painstakingly prepared magnetic charts as those of the Admiralty are substantially out of date and misleading, both to navigators and to scientists concerned with geomagnetism.

Magnetic surveying establishes the average value of the geomagnetic components over many small regions of the earth. The results are smoothed somewhat and plotted as a magnetic chart showing lines of equal magnetic force. An accumulation of surveys enables a measurement of the speed and range of the secular (or long-term) changes in the earth's surface field to be made, and so helps charts and correction tables to be-

come increasingly accurate and meaningful. The degree of these secular changes varies very considerably from place to place. It is known that in some regions the field-strength changes by as much as a third in a century. In addition, without fairly frequent review of the three magnetic components all over the world it is impossible to tell whether a recorded change in the reading is due to secular variation or is a short-term and sporadic effect.

The problem of keeping track of magnetic changes over the land surfaces of the globe is not too troublesome. There are now 200 observatories maintaining continuous magnetic records; before the IGY there were ninety. Almost all of the additional stations are expected to continue permanently. (It is worth noting that before IGY there were only fifteen geomagnetic observatories throughout the whole of the southern hemisphere; now there are fifteen in the Antarctic alone.) In addition, a number of countries carry out overland surveys periodically; the last one made in Britain was in the early '30s. The principal gaps in the network lie over the two-thirds of the earth covered by water. So the main difficulty in organising a world-wide magnetic survey resolves itself into getting sufficient measurements at sea and within a sufficiently brief period. To add to the difficulties, modern ships are made of magnetic materials and so are unsuitable for making geomagnetic measurements.

Passage of Windscale's Cloud

During the symposium on Nuclear Radiation (XIV) at the Moscow meeting, P. A. Sheppard, Professor of Meteorology at Imperial College, London, gave an account of what happened to the radioactive cloud that was formed as a result of the accident to No. 1 reactor at Windscale, Cumberland, last autumn. "Accidents will happen but we might as well make the most of them." With this approach the nuclear radiation network that has been making IGY measurements was alerted immediately and was able to track the cloud as it passed over England and to observe its dissipation over the Continent.

The accident took place on October 10, 1957, and the bulk of the emission occurred between 12.00 hours on the 10th and 09.00 hours on the 11th, in a period of nearly twenty-four hours. Iodine 131 (half-life eight days) was the predominant radioactive isotope in the emission and was the principal isotope measured by the stations; however, there were some measurements of caesium (which has a half-life of thirty years). The nuclear radiation in the air just above ground-level was measured, the air being sucked through filters.

When emission started the winds in the Windscale area were south-west; soon after they swung round to easterly and then went back to the south-west once more. By the midnight after the accident a cold "front" advancing from the north-west actually lay across Windscale; the wind was now blowing towards the south-east. The cloud thereupon travelled down and across the country, passing London and then the Channel and was tracked across Belgium. By the time the cloud extended 120 km. to the south of Windscale it had already spread out to 150 km. wide—in other words the "spread" of the cloud was considerably greater than the "travel". This is quite contrary to "model cloud behaviour" and is, therefore, an interesting case to meteorologists, who seldom have an opportunity of tracking clouds in detail in this way. Here the large spread arose primarily from the great changes in wind direction during the early part of the emission.

The measurement of the cloud's radioactivity was in micro-micro-curies × days per cubic metre. The highest reading registered was 1030 of these units, on the Mersey. Two readings in the Lake District gave 803 and 728. The cloud reached London early in the morning of October 11. By now it was travelling slightly behind the "front". The radioactivity measured 431. Front and cloud continued their journey together across the Channel, and a few hours after passing London were over Belgium. Over Belgium the cloud became a double-cloud. Measurements of its radioactivity in the Low Countries gave values between 30 and 50 units—in other words the values had dropped by an order of magnitude in the brief period and distance of crossing the Channel. On the whole it seems that the bulk of the cloud was left behind over England. Other measurements on the Continent (there were not many) are as follows: Paris, 3; Austria, 0·6; Italy, trace; Spain, 0; Denmark, 0·3; Norway, 0·7; Sweden, 1·6.

It has been estimated that the total radioactive emission from the damaged reactor was 20,000 curies, and that about 13,000 curies of this was deposited on England. Concentrations in grass were measured at many stations, roughly in a line, St Davids, Oxford, and Cromer. It is estimated that between Windscale and this line 5000 curies were deposited.

These measurements raise two questions: What was the cause of the big drop in radioactivity across the Channel? How to account for the cloud's overall behaviour, so different from that of the postulated "model cloud"? It is hoped that further investigation may answer both questions.

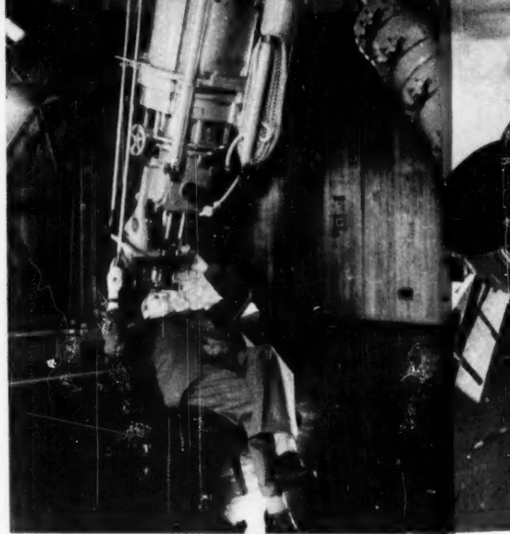


FIG. 3. Telescopes which were once mounted at Greenwich have been re-erected at Hurstmonceaux Castle, Sussex. The move has been going on for some years and is now complete. The telescopes are housed in the specially constructed domes built in the castle grounds. The photograph shows Dr Richard van der Riet Woolley, the Astronomer Royal, on a couch, studying through one of the 28-in. equatorial telescopes at the new observatory.

More *Sputnik* Results

During October a long article was published in *Pravda* giving preliminary results from *Sputnik III*. Both instrumented nose-cone and rocket are still in orbit and the *Sputnik*'s radio is still working. On October 4, the anniversary of the launching of the first earth satellite, the nose-cone completed its 1956th orbit of the Earth and the rocket the 2001st.

We here summarise the principal findings as published by *Pravda*:

Aerodynamic Effects: If the region in which the body is moving were a genuine vacuum and the *Sputnik* was not acted upon by atmospheric and other disturbances, its movement would follow a regular precession as it has a symmetrical axis. The satellite would rotate evenly about its longitudinal axis, which, in turn, would revolve round the other axis (the axis of precession), which is stationary in space. Analysis of orientation data derived from visual observations of "fading", from magnetometer readings which establish the *Sputnik*'s position in relation to the Earth's magnetic field, and from other calculations, shows that this is not so. The direction of the axis of precession is not stationary in space but alters slightly. The longitudinal axis forms an angle of 84° with the axis of precession. The period of precession is approximately 140 sec., and period of

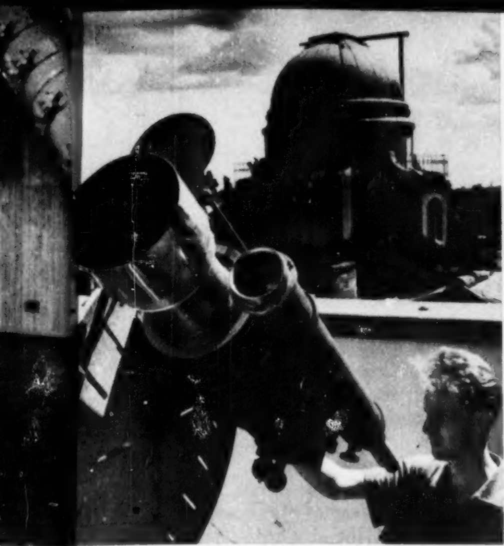


FIG. 4. The Astronomic Institute at Ondrejov, near Prague, is one of the stations taking part in the International Geophysical Year. Chromospheric eruptions of solar activity have been observed there by means of a spectrohelioscope since 1948. For the past nine years more than 1300 eruptions have been observed from the Institute. In addition to visual observation, photographs are of course being taken. Figure shows apparatus designed for photographing the spectrum of meteors and comets; the spectrum of the Arent-Rolland comet was recently obtained.

rotation about the longitudinal axis about 18 min.

Analysis of the satellite's deceleration in orbit shows variations which correlate with changes from day to night and with latitude. When perigee moves from noon to night, there is apparently a decrease of more than one and a half times in the product of the atmospheric density, and the square root of the height of the homogeneous atmosphere. A similar result came out of a study of the deceleration of *Sputnik II*. This also showed a decrease in atmospheric density from northern to southern latitudes.

Atmospheric Density: It has been found that at a height of 266 km. the density of three ten-millionths of a gram per cubic metre. This is approximately one ten-thousand-millionth of the density at the Earth's surface. These results agree with density values derived from study of the *Sputnik's* deceleration also. These density values are between five and ten times greater than those assumed before data from Earth satellites was available. The density drops by about 90% a hundred km. farther up (that is at about 370 km.).

Ion Composition in the Ionosphere: By means of a radio-frequency mass-spectrometer it has been possible to separate the components of the ionised gases between 230 and 950 km. up. Ions of atomic oxygen predominate in this region; ions of atomic nitrogen are also present but their quantity is only 3% to 7% of that of oxygen. At the beginning of the flight, ions of water vapour were also detected by the instrument but this is thought to be due to the water carried on the surface of the *Sputnik* itself into the upper atmosphere on its flight into orbit. "However, the fact of the ionisation or evaporated water in the upper atmosphere remains a mystery."

A detectable number of ions have been observed in the region of 1000 km., where, it used to be thought, the Earth's upper atmosphere changes to the emptiness of interplanetary space.

Degree of Ionisation: It has been possible to deduce from the information obtained from *Sputnik III*'s ion traps what the temperature of the electrons in the upper atmosphere is. It has been found that the temperature of ionospheric electrons is much higher than that of neutral particles and ions at these altitudes. This unexpected result is not yet accounted for. One suggestion has been made—that the high electron temperature is due to the existence of variable magnetic fields.

The measured negative potential of the *Sputnik*'s surface at an altitude of 795 km. in the day proves to be roughly 6 V; the concentration of positive ions at this altitude approximately 160,000 ions/cu. cm. At 242 km. the *Sputnik's* potential is about 7 V and the ion concentration 500,000 ions/cu. cm.

Electrostatic Measurements: The intensity of the electrostatic field in the upper atmosphere has proved unexpectedly great—at least ten to one hundred times greater than the assumed value, in fact. This finding, which requires considerably more study, may throw light on some of the less understood processes that take place in the ionosphere; for instance, the causes of ionisation at night.

It was also found that the electrostatic charge on the *Sputnik* itself was greater than anticipated. The *Sputnik*'s electrostatic charge has proved to be a negative charge.

Magnetic Measurements: It has been found that the East Siberian geomagnetic anomaly fades very slowly with height. This does not support the hypothesis that the sources of this continental anomaly reside in the upper layers of the Earth's crust.

Brief but rapid changes of the magnetic field have been detected which appear to coincide with the passage of the *Sputnik* through the F layer of the ionosphere. It is thought these rapid changes may be due to current systems that are assumed to exist in the upper atmosphere. Further study of this problem is envisaged.

Density of Meteoric Material: The *piezo* recorders used—they total an area over the *Sputnik*'s surface—have shown an average of one hit per 100 sec. or a little longer. This corresponds to a density of meteoric material of less than one ten-thousand-millionth of a gram per square metre of surface per second.

Photons in Cosmic Radiation: A sharp change in the number of photons recorded was observed at approximately 60° N. With the satellite moving in a south–north direction the intensity was fairly stable between 300 and 500 photons/sec. and then sharply increased in the vicinity of 60° N. In a north–south direction the opposite occurred. This latitude is close to the auroral zone, so it is natural to connect this phenomenon with aurorae.

The Cherenkov counter registered two groups of **cosmic-ray nuclei**, those with a charge of 16 upwards and those with a charge above 30. It appears that the first group occur at the rate of 1·2/sec. Only one nucleus with a charge of more than 30 has been recorded. From this it is shown that there are roughly ten thousand times less atomic nuclei heavier than iron in the cosmic-ray spectrum than there are nuclei of iron, nickel, and cobalt. This agrees reasonably well with the ratio of the elements known to be present in the universe as a whole.

Corpuscular Emission. Photo-multipliers designed to register incoming solar corpuscles such as those assumed to cause the aurora, have in fact detected electron streams of great intensity thought to come from the Earth's own atmosphere and accelerated by spiralling in the geomagnetic field. The velocity of the electrons precludes their being associated with solar corpuscles. The intensity of the streams varied continually; increases were observed with altitude and above high geomagnetic latitudes. The energy of the electrons is estimated to be of the order of 10,000 electron-volts, but not infrequently it is thought the energy was even greater—when the recorder went off the upper end of the scale.

In addition, the cosmic-ray photon-counter was at intervals prevented from registering cosmic rays because of the interference caused by the incidence of hard electrons on the *Sputnik*'s body; instead it provided material on the electrons of the upper atmosphere.

Lowest Temperature Record Beaten

In August the Soviet Antarctic station of Vostok, near the Geomagnetic Pole, registered −125·4°F, the lowest temperature ever recorded at ground-level.

Since international geophysics on a large scale is to continue, DISCOVERY *has decided that the Geophysical Notes should also continue after the end of this year. There will be a new title but a similar style and presentation.*

THE BOOKSHELF

Living Resources of the Sea*

By Lionel A. Walford (*New York, The Ronald Press Company, 1958, xv+321 pp., $6.00*)

The first thing to be said about this fine book is that it was badly needed; the second is that it has been excellently written by the right author! Too often when conversations have turned to speculations whether the food available over the earth will suffice in years to come for a greatly increased total human population, one has heard the airy facile remark that the seas will be able to provide enough. The theme of this book is that if it be desired to exploit the sea fully, and if knowledge be requisite to accomplish that purpose, then the necessary costly investment and full effort to acquire it had better be made right away. No reader acquainted with the author will be surprised to find that the book is not only a mine of information about what is known, but is also a penetrating exposé of what must be learnt germane to the very important theme. Dr Walford is a very experienced aquatic biologist with nearly a quarter of a century in his country's Fish and Wildlife Service behind him.

A very useful feature of this book is the provision by the author of chapter headings which really do give a pithy summary of what follows. Admirable also is the fact that the synopsis printed on the dust jacket is just what it should be: a true, fair, and modest indication of the book's purpose and content.

Impressive aid to Walford's systematic appraisal of what is known and what still remains as a "must" to be learnt about the sea and its inhabitants, is afforded by twenty-three chartlets specially prepared for the volume. These cover broad subjects, such as the influence of varying environments, the behaviour of marine organisms, and the role of conservation.

There is a foreword by Fairfield Osborn who is President of the Conservation Foundation under the aegis of which the book has appeared. Fairfield Osborn very rightly remarks that, instead of presenting only compendia of accumulated knowledge, the author "with restless purpose" seeks to make greater demonstration of what is not known but must be learnt towards the end of meeting the compelling need of mankind "for the immeasurable quantities of self-generating resources that could be drawn from the oceans".

With the world's population increasing by 40 million mouths annually, the urgent and essential value of the book under notice lies in its contribution to the thought and action required before the pressing needs of human beings can be better satisfied. Those words are also Fairfield Osborn's, but perhaps the best thing said in his foreword is where, remarking that the author is "sensitive to conditions affecting human welfare" he puts his finger upon the very reason why such a book could be conceived and written so well. Walford is well aware that there is no easy way of dispelling the vast ignorance at present existing and pays tribute to the work of FAO towards that end. He tells us that the present harvest of marine fishes, invertebrates, and algae, is about 26½ millions of metric tons a year, and states that, merely to maintain the present *per capita* consumption in step with increasing population, an additional production of some 8½ million tons will be required over the next fifty years.

Having asked whether it is inevitable that the majority of people in the world should never have enough to eat, he tells us that a 50 million ton increase over the same period would be necessary to redress the present starvation.

Turning from the general to the particular as we must do to convey something of the book's contents: it is to be remarked that Walford devotes five chapters to concise summations of present knowledge about the sea's invertebrate animals, its fishes, its mammals, its reptiles, and its useful seaweeds. Stimulating chapters are devoted to the practical problems needing solution; amongst these are the roles of disease and poison, of plankton-harvesting, of "farming" the brackish water regions, and of improving fishing vessels and their gear.

Basic to all that the author says is his conception of the sea as a wilderness, full of secrets, inhabited only by wild animals, and almost entirely uncultivated.

Though enough has been said to occupy the space allowable, nothing like enough has been written to do justice to a book whose worthy theme receives masterly treatment throughout its sixteen-score pages.

J. N. CARRUTHERS

* See p. 489.

Travaux Publics de France*

By Jean Claude Fournet and Serge Hyb (*Paris, Editions Science et Industrie, 1957, 112 pp.*)

As a supplement to the journal *Travaux*, this album, containing some 150 photographs of recent French civil engineering works, has been published under the auspices of the Syndicat Professionel des Entrepreneurs des Travaux Publics to mark the 75th anniversary of this Association.

The first part of the album consists of photographs, mostly in photogravure but some in excellent colour, showing fifty works completed between 1945 and 1957 all of which can claim a world or continental record for span, height, and so forth. This form of presentation is perhaps somewhat naïve, but there is nothing immature about the structures themselves nor is one tempted for a moment to think that their designers were taking part in some kind of pointless competition. In the second part the illustrations consist of a greater number of works chosen for their intrinsic importance or beauty.

In the 17th and 18th centuries the French were beyond doubt the greatest civil engineers, and it seems probable they have regained this distinction in the mid 20th century. Other countries may turn out more work, and complete it more quickly, but what compels admiration in these French bridges, dams, and buildings is the logic, the absence of fuss achieved without becoming bleak, and the imagination, even the daring invention, displayed in their design. In a word, the best French engineers are artists as well as technologists.

Nothing is to be gained here by choosing a few of the works illustrated for special mention. The general standard is extraordinarily high and one realises that such outstanding men as Eugène Freyssinet and André Coyne are the leaders of a truly formidable national school of design.

A. W. SKEMPTON

Air Pollution

Edited by M. W. Thring (*London, Butterworths Scientific Publications, 1957, x+248 pp., 42s.*)

The Clean Air Act, 1956 is now the law of the land, the final regulations concerning the emission of dark smoke mainly from industrial chimneys having come into force on June 1, 1958. The new legislations means a great step forward in the hitherto rather futile struggle against the fouling of the atmosphere. To implement

* See pp. 492 and 493.

the law in the strictest sense would call for Draconic policing, a procedure both abhorrent to this liberty-loving nation and ineffective in its results.

The full benefits of the Act, even in its limited coverage, can only be realised by wholehearted co-operation of the public, and this in turn calls for education of all fuel consumers, domestic and industrial alike, in the wise, efficient, and unoffending use of coal, coke, and oil.

Such education must be based on spreading our existing knowledge of the causes, incidence, and effects of air pollution and of the means of preventing or curing it. Further, this knowledge must be widened by more extensive and more intensive research into the many problems remaining as yet unsolved.

With this objective in view, the present volume must be welcomed. It is based (with one exception) on papers given by experts in their respective branches in a course on air pollution held at the University of Sheffield in September 1956, organised by the editor.

Under the main headings of the nature and consequences of air pollution, the dispersion of discharged gases, the elimination of pollutants from industrial plants and vehicles, and the relevant legislation, the authors present the various sections of the wide field in an authoritative and readable manner. Most of the articles, though concise, cover the subject-matter adequately. The book differs in that respect from the more voluminous compendia published in recent years, particularly in America, for the use of the specialists. Rather should it appeal to that wider circle of those concerned with the administration of the new legislation, the designers and makers of appliances and plants, the purveyors of fuels, and not least to fuel consumers upon whose willing and active co-operation success in clearing the air will mainly depend.

The inclusion of a chapter by Alice Garnett on geographical factors might be mentioned in which the effects of pollution on climate are discussed, a subject deserving more attention than it has received in the past.

Sir Hugh Beaver, the Chairman of the Air Pollution Committee which bears his name, in a foreword stresses the importance, and indeed the necessity, that the appropriate apparatus of technical and scientific thinking and research should be mobilised to find the answers and apply the means for solving the technical problems set by air pollution.

The information given in the Sheffield lectures as recorded in this book is a useful contribution to the available literature. It will be of value to a wide circle of readers and will stimulate the interest of those directly or indirectly concerned in the attack on a great social and economic evil.

R. LESSING

Engineering Materials and Design

A Heywood Publication (*2s. 6d. monthly*)

The publication of a new trade or technical journal is not always cause for congratulation, for many seem to serve little purpose beyond relieving their advertisers of excess profits.

Moreover, some fields seem almost too well covered by competing but similar publications, with the result that the already harassed business executive becomes overburdened with paper at weekends and on train journeys. One might have thought that the engineering field was one of these, for there must be fifty or more journals covering some aspect or other of the engineering industries. And yet those indefatigable publishers, Heywood & Company Ltd, have decided to send out one more engineering monthly from Drury House, whence are already issued so many well-established journals covering the widest range of trades and industries.

All publishing is more or less a gamble; it becomes less so only if there is an obvious gap to be filled and if the new journal is properly tailored to fill it. To judge from the first issue of *Engineering Materials and Design* Heywood & Company Ltd have found just such a gap and their editor has measured it well. There is no doubt that design, not only in the sense of exploiting new materials and processes but also in the sense of appearance or convenience in use, is fundamental to successful engineering development. Many people would agree that a long history of industrial production and several generations of successful leadership have tended to lull many British engineering companies, particularly, perhaps, those making essential conventional equipment, into a false sense of security with a consequent conservatism in approach to design that could, unless checked, lead to trouble in the face of lively foreign competition.

It is largely to meet this problem that this new publication seems to have been planned. It is aimed at the engineer, at the engineering draughtsman, and at the industrial designer who hopes to practise in the field of design. By drawing attention to new materials, new processes, and new equipment it will offer the engineer-designer a quick reference to possibilities he might not have contemplated. At the same time one hopes that by comparing different solutions from different countries it may from month to month draw attention to the most worth-while trends and developments, for comparison is often the healthiest spur to fresh invention.

If this first issue should be criticised, it might be on the score that it lives very well up to the first part of its title—"Engineering Materials"—but not quite so well up to the second—"Design".

P. REILLY

List of current publications of Academia Sinica (Peking, China)

The following periodicals are published bi-monthly:

(*a*) In Chinese with abstracts in foreign languages:

Acta Physica Sinica

(*b*) In Chinese:

Researches in Economics
Archaeological Bulletin

The following periodicals are published monthly in Chinese:

Science
Historical Researches

The following periodicals are published quarterly:

(*a*) In Chinese with abstracts in foreign languages:

Progress in Mathematics
Chinese Journal of Civil Engineering
Acta Mathematica Sinica
Acta Chimica Sinica
Acta Agriculturae Sinica
Acta Phytotaxonomica Sinica
Acta Botanica Sinica
Acta Palaeontologica Sinica
Acta Geologica Sinica
Acta Entomologica Sinica
Acta Geographica Sinica
Acta Meteorologica Sinica
Acta Metallurgica Sinica

(*b*) In foreign languages:

Scientia Sinica

(*c*) In Chinese:

Researches in Philosophy
Acta Archaeologica Sinica

The following periodicals are published semi-annually in Chinese with abstracts in foreign languages:

Mechanical Engineering
Acta Pedologica Sinica
Acta Zoologica Sinica
Acta Astronomica Sinica
Acta Pharmacologica Sinica
Acta Experimentali Biologica Sinica
Acta Hydrobiologica Sinica
Acta Geophysica Sinica
Acta Microbiologica Sinica
Acta Phytopathologica Sinica

The following periodicals are published annually in Chinese with abstracts in foreign languages:

Acta Physiologica Sinica
Acta Anatomica Sinica

The following periodical is published irregularly in Chinese with abstracts in foreign languages:

Acta Palaeontologica Sinica

SCIENCE ON THE SCREEN

Static Film Strips are Dynamic Teaching-aids

This month I have seen three new film strips, two in colour and one in black and white. They were all produced by Common Ground (1951) Ltd and distributed in the United Kingdom, Crown Colonies and Mandates by the Educational Supply Association. As usual, they are thoroughly workmanlike, but this does not mean that they are above criticism. Studying film strips in relation to their teachers' manuals one is faced with the immense difficulty of making good film strips. Personally I would much rather script and direct a film, as it is so much easier to obtain a dramatic or didactic effect when one's shortcomings hide behind the veil of movement.

Colour, too, presents a problem. It needs almost complete black-out to obtain a reasonably degree of colour accuracy. Even the faintest line of light on the screen produces an amazing fall off. So the strip- and film-maker must justify the value of colour to the teacher with complete objectivity. Two of these strips are in very good colour, and it seems to me that its use is justified. Colour is most effectively used for identification, atmosphere and reality. For example, if electrons are shown in one colour and protons and neutrons in other colours the audience can immediately identify them, as soon as the code has been accepted and learnt. A greater warmth and sympathy can be evoked if objects are shown in natural colour. In an agricultural strip the colour of the chicken may make it seem real and natural and the paleness of its drooping comb may show that it is sick. On the other hand if the object in the foreground is important, colourful mountains in the background or the bright shirt of a geologist may draw the eye away from what the audience should be looking at.

Before coming to a description of the individual strips I feel I must be rather critical of all the three manuals. These criticisms, in fact, apply to 90% of all teachers' manuals that I have ever read. Why must they be so invariably dull? The subject-matter of all three is of great interest, pertinent and complete, but the style! In each case it is either turgid or pompous. I had to make an effort of will to read them from cover to cover. Many sentences were so long and cliché-ridden, that I had to begin them several times before I could interpret them. This type of writing is unnecessarily unattractive for tired teachers to read, and it makes the task of using visual aids unnecessarily arduous. Just a little more lucidity and simplicity would pay dividends, for it would help the teacher who does not use projected material to make up his mind how valuable it can be. It would also be useful I think if the manual, or the strip itself, gave an idea of the age-groups at which the strips are aimed.

Oil in the Middle East

By G. H. Dury and T. J. Chandler in the series "Geography and Colours". 25 frames with teachers' notes. (*Issued by Common Ground (1951) Ltd. Price £1 7s. 6d.*)

A combination of maps, photographs and diagrams tell the story of a great industry in one of the trouble spots of the world. Avoiding politics it shows clearly by well-chosen visuals how oil is won in the Middle East. It is a discipline to deal with a complex subject in twenty-four easy pictures. It is no easy matter to decide how one static picture can express a whole stage in oil production.

I am not certain that I agree entirely with the choice of visuals, but it would be difficult to suggest better. If one considers the number of moving pictures about oil produced by the industry, and

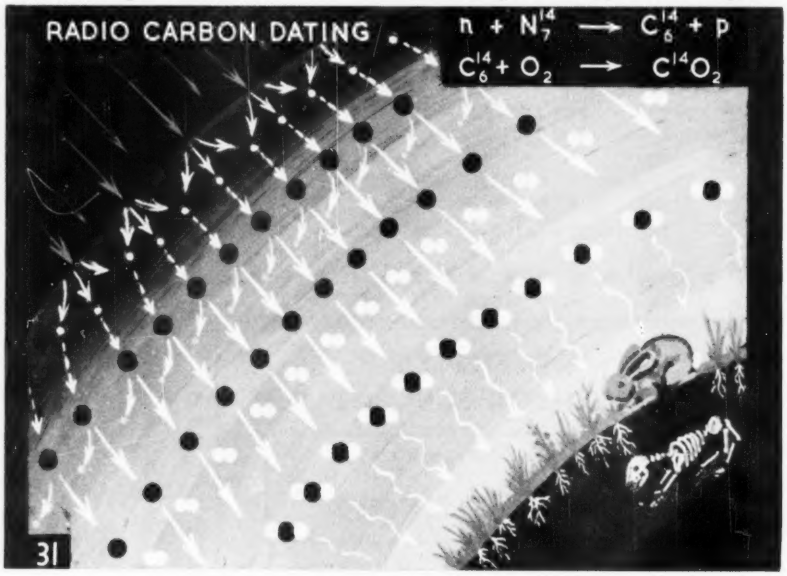


FIG. 1. Frame 31 from "The Structure of Matter".

FIG. 2. Frame 21 from "The Curies and Radium".

available on free loan, undoubtedly this strip can be used as an excellent introduction to the subject.

Extraneous images have been rigorously excluded and the camera has always come in close enough to show the important details. I consider this an asset, for irrelevancies are one of the greatest crimes. The diagrams are clear and easily understandable.

Unfortunately, to return to the manual, the writers never use one short word when three long ones will do. The writing is not a commentary but a rather Victorian description of the contents, full of phrases like: "as will be noted later", and "in addition it should not be forgotten", and "it is enough to underline". The information is all there but the teacher has to dig for it.

In comparison with the clear-cut use of line and colour in the pictures the manual does not seem to come from the same source. If only the sentences could use the same simple exposition that the photographs and diagrams do, I would have practically nothing to criticise. Undoubtedly this is a valuable addition to the very large quantity of material already available on this great industry.

The Structure of Matter

By C. A. Vernon and A. L. Dahl in the series "Physical Science". 35 frames colour with teachers' notes. *(Issued by Common Ground (1951) Ltd. Price £2 2s., special)*

The diagrams in this strip are so clearly and simply designed that they help to make complicated concepts comprehensible. The use of dark backgrounds make the images stand out with authoritative clarity. From a teaching point of view some of the frames pose such complex propositions that students may find themselves drifting away from the main theme in a sea of distractions. For example, Frame 5 shows a sectionalised world on which the development from a molten mass to the present day is shown. This is to illustrate that it would take a cosmic being [*sic*] counting two atoms a second 3000 million years to count one-hundredth of the atoms in a grain of salt. This idea is awe-inspiring and effective, but seeing the development of our planet and of life upon it, could easily capture the imagination, leaving the grain of salt in outer darkness.

All the same the direct and skilfully scientific exposition should be of great assistance in the teaching of physics. Although I can imagine no one lesson in which all the information in this strip would be given, rather I feel, this strip could supply support for a term's work.

The teachers' notes are detailed and clear but once more I would crave a little more attention to literary style.

The Curies and Radium

By J. A. Lauwerys in the series "Lives of Famous Men and Women". 44 frames black and white. *(Issued by Common Ground (1951) Ltd. Price 16s. 6d.)*

This strip combines period photographs of the Curies' life and work with diagrams illustrating their scientific discoveries and the significance of their work to modern science. Every frame gives the impact of integrity, the acknowledgements in the beginning of the teachers' manual show why: all the material has been produced in conjunction with the Curies' biographers, family, and the most authentic sources available. The teacher using this strip would have to study it very carefully in order to incorporate all the information in the thirty-four relevant pages. Most people would find it better to paraphrase the manual into words suitable to their class and to put the commentary on to tape so that it could be used as a sound film strip.

I experimented myself and found that working in very low light it was difficult to read the notes, or even turn them into my own words, without considerable preparation and study. I believe that these strips about famous people should wherever possible have a commentary or even dialogue recorded on disc or tape, as this would considerably increase their impact while lessening the teacher's work.

The problem in this and in most other similar cases, is a question of expense and expediency. Still it is to be hoped that the ever-increasing complexity of the syllabus will force financial authorities to grant more and more money to the development and use of new teaching materials. It is well to remember that closed-circuit television could well become the modern blackboard for science teaching in the ordinary school. L. GOULD-MARKS

Autumn Television

Now that autumn has come, with its longer nights and its bigger viewing audiences, the BBC is going ahead with scientific TV broadcasts, although unfortunately the other channel has remained silent. During the past month the BBC has given us no less than one broadcast a week in the series "Eye on Research", which is edited by A. E. Singer, and two new broadcasts entitled "Science is News", which appear fortnightly under the production of J. McCloy. Both producers are old hands with scientific programmes.

Most of the content of the whole series of "Eye on Research" deserves some praise. For instance, we had a difficult programme on clouds and the weather. This resolved itself largely into a two-way conversation of question and answer with demonstrations between that admirable interrogator, Raymond Baxter, and Dr Mason, cloud physicist at Imperial College, London. The broadcast therefore concentrated, to considerable advantage, on the work of one scientist in one laboratory. There were some direct experiments on the formation of cloud and ice but these did not register too well on the cameras and as a broadcast were indifferent. Fortunately some speeded-up film on snow crystal growth amply compensated for this defect. The broadcast was at times marred by an excess of technical terminology and it was certainly over-ambitious when it attempted to explain to the layman the meaning of epitaxy in connexion with cloud seeding. The scientific background of even a well-educated audience is very restricted and this is only too frequently forgotten by science broadcasters.

This was a good average programme, certainly well worth seeing but hardly a star attraction, nor was it very exciting. Perhaps no one can really be expected to be excited about so miserable a subject as our weather.

The programme on October 28 was a most unusual and exceptionally delightful broadcast. The title itself was curiously intriguing to begin with, "The Six Parameters of PAT". The programme turned out to be an absorbing half-hour about experimental phonetics and artificial speech production, speech entirely without intervention of a human voice, but built up entirely by wave-forms. PAT, we learnt, was the now popular initial nomenclature for "Parametric Artificial Talker", a somewhat forced name, it must be admitted, for what is after all merely a harmonic synthesiser. This electronic-acoustic machine, designed and operated in the Department of Phonetics at the University of Edinburgh, gave a practical demonstration. The whole admirable programme was virtually carried by Dr D. Abercrombie of Edinburgh. He was most careful to explain all the technical terminology he was obliged to use, and did so economically and succinctly. He started dramatically by appearing on the screen with a rubber tube passing up his nostril which ended, as he later showed, with a balloon in the oesophagus for measuring speech air-pressure whilst articulating. He lectured unconcernedly and nonchalantly with this awkward appendage and showed in a delightfully clear way, with an oscilloscope, how various sounds produced a variety of pressure pulses.

He followed this with a direct display into the camera of his vocal chords in action, following with slow-motion film.

This direct demonstration of the moving vocal chords was indeed a first-class piece of camera work, for clearly quite a formidable illumination problem had to be solved, and solved it was.

This was really first-class science television, intimate, personal, and highly informative. Such content is infinitely superior to seeing vast wind tunnels in operation, or awe-inspiring atomic reactors, or large complexities like ZETA, or space rockets, for that matter. It was intimate to such an extent that it was possible to forget the very medium used and believe oneself to be in the self-same room as the subject whose throat was being watched.

Then Dr Abercrombie came to his main theme, illustrating with an oscilloscope that six parameters, pitch, loudness, hiss, and three characteristic overtones, really formed each of the speech sounds. On the basis of such observations, information was fed into PAT and it spoke back in a most creditable fashion, not merely vowels, but recognisable complete words. Viewers were asked to write back on a post card the words heard and this should prove helpful in analysing the performance of the machine. No doubt thousands of replies will be received. In spite of the obviously purely academic character of the research, practical aspects were not lost sight of and the possibilities in connexion with correction of speech defects and so on were emphasised. The implications to electrical communication of speech were discussed by Mr W. Lawrence.

The success of this admirable broadcast lay essentially in three factors: (1) the content was exciting; (2) there was detailed concentration on one specific research; (3) the critical importance of the individual as an investigator rather than the team was made very evident.

In the opinion of your reviewer, the "Science is News" programmes seen so far fall rather short and in parts they have almost adopted the level of Snappy Scientific Snippets. We have been given as a sub-title, "Television Reports on Discoveries in Science, Medicine and Industry which are changing our World". This seems an ambitious title for some of the subjects so far treated. Some of the reports are short and breathless and may well give a wrong impression of how scientific research is being carried out. By their very nature such rapid flashes must invariably fail to indicate the patient, long-term, back-breaking spadework behind almost every significant research of today. Some of the reports almost give an impression that scientific research is "hot news", that the investigator is very much like the Digger down under, suddenly making a lucky strike whilst prospecting unlikely fields. Of course nothing could be further from the truth.

On October 16 the programme opened with shots from the Unit of Applied Psychology at Cambridge, illustrating dubbed film showing eye movements (similar film has been shown on TV before). Then followed a tolerably interesting film description of aircraft landings. Then, quite inconsequently, the programme switched to enormous close-ups of what was called the "Menace of the East", that is, locusts. They were shown mating and depositing their eggs, without much comment. After this veritable snippet there appeared on the screen what your reviewer happened to recognise as a coronograph speeded-up film of solar prominences, but this was not explained or described, but it was, strangely enough, introducing viewers to ZETA. Standing alongside each other without comment, this must have possibly raised strange associations in some people's minds. Dr Thoneman, who directed the ZETA researches at Harwell, was then interviewed about thermonuclear research. Once more we encountered our old enemy, the unexplained technical terms, such as "plasma", "heavy-hydrogen core" and so forth.

Ten minutes remained so a new subject was introduced, and this was both entertaining and good. Our familiar Doctor friend of BBC science TV broadcasts gave a detailed and efficient explanation of the connexion between bodily motion and the act of vomiting. Together with Dr Glaser he showed some attractive film of volunteer soldiers submitting themselves to drug control experiments and being savagely rocked on rafts in a naval hydrodynamic tank activated by a wave-making machine. This ended with an amusing rocking of the camera which indeed made the viewer feel quite giddy, as was of course intended.

The next Science News programme, on October 30, was also marred somewhat by its restless broken character, which was unfortunate as it contained some really exciting material which could have been exploited for the whole of the time available. Patrick Moore reported on the possible existence of radiation danger from forward-scatter radio-frequency techniques which has come recently into the news. Your reviewer does not think that a matter which is still *sub judice* scientifically is suitable material, as yet, for scientific popular broadcasts. Until the situation has crystallised itself on technical grounds, arguing about it can only confuse the layman, indeed it can raise false hopes or create false fears. There is enough well-established material without being concerned with what might eventually turn out to be a red herring. Patrick Moore, usually an excellent broadcaster, went through his material much too quickly, though possibly the allotted time had a lot to do with this.

The next ten minutes proved very exciting indeed: an interview with Dr Anne McLaren, who has had considerable success in transplanting fertilised eggs from one mouse to another and rearing thereby healthy offspring within a foster-mother (see DISCOVERY, 1958, p. 423). Such experiments have enormous possibilities in animal husbandry and the experiments were described in a delightful manner with clarity and precision, using excellent film and some diagrams. We regretted indeed when this absorbing feature was cut short, for a film showing merely crowds at the current Earl's Court Motor Show and some ordinary slow-motion film of car wheels passing over road bumps. Indeed this was a case of precious minutes wasted on precious little.

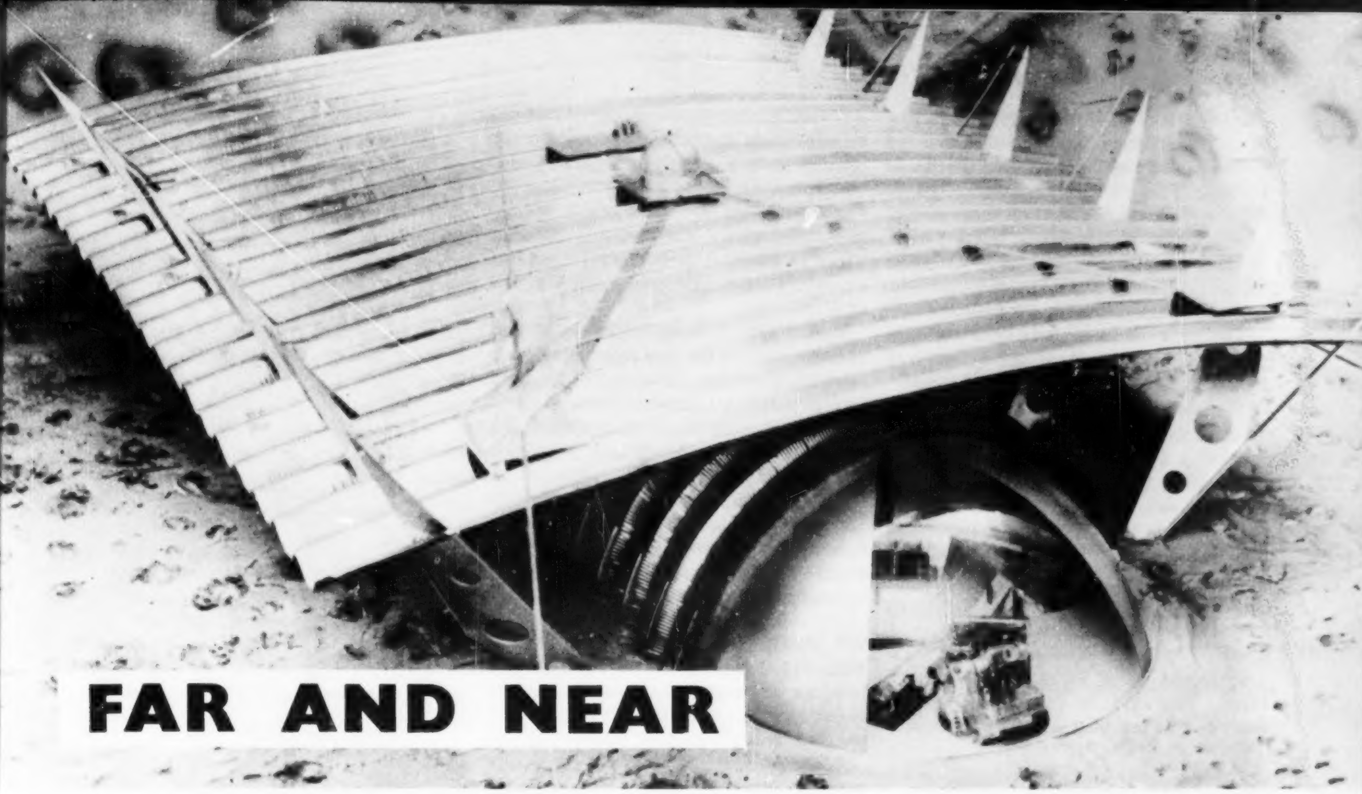
The broadcast ended with Dr Margisson interviewing Sir Edward Bullard on the methods recently proposed at Geneva for the detection and control of atomic-bomb explosions. A good deal of basic physics and geophysics was covered in this all-too-brief discussion. The time available was undeniably far too short for the complexity of the topic.

Had the whole broadcast been restricted either to the egg transplantation or to the detection of atomic explosions it would have served a more meritorious purpose. The prime question the BBC must ask is, should it educate or should it entertain? It will be agreed that the viewer is virtually swamped with entertainment of one kind or another and the precious hours devoted to science must categorically be employed educatively. The idea of an entertaining science broadcasting service should be strongly discounted. The snippets fall short of the best possible use of camera time. Current scientific research is so formidably technical that any single research of significance demands a minimum of half an hour for its exposition to the layman. The reviewer does not believe that viewers will be at all bored by concentration on the one subject, but that they are likely to benefit from such and appreciate the fact.

S. TOLANSKY

Erratum

We regret that in our article, "Automatic Flight Control—Past, Present, and Future" (DISCOVERY, October, vol. 19, p. 410), Fig. 1 was credited to the Decca Navigator Co. Ltd. This photograph was kindly supplied by the de Havilland Aircraft Co.



FAR AND NEAR

"MOON BUILDING" MODEL

The plastic bubble observatory in the foreground is protected by metal sliding doors from intense ultra-violet radiation. Upper section over structure is a protective meteoric shield, designed to ward off gnat-like rain of interplanetary meteoric dust which descends with great velocity on the barren surface of the Moon. Dome in centre of barrier is the traffic control tower. Built to a scale 1 in. equals 10 ft., moon building would be 340 ft. wide and 83 ft. high.

Science and the Unions

The growing interest which the TUC is taking in scientific matters is a most welcome development, for scientific progress depends not only on a growing supply of scientists and technologists, but also on the widest possible propagation of the scientific gospel throughout the rank and file of industry. The TUC's concern in matters of industrial research —as their General Council's report to this year's Congress clearly shows—is a two-fold process: at the higher levels, participation in the establishment of scientific policy, and at member level, the provision of data on the role of science and research in industry. Hence the General Council has two representatives on the Council of the DSIR, while the individual trade unions have some form of representation or connexion with nineteen of the forty-eight industrial research associations. For its part, the General Council has its own Scientific Advisory Committee: this is a mixed committee, partly lay and partly scientific, comprising General Council members and eminent persons in the scientific world. It advises particularly on the implications of nuclear energy development on the fuel and power problem, while a special trade union interest which has received much publicity and debate is that of radiation hazards in industry and the need for a comprehensive safety code for the workers.

The TUC's advice has been sought on a number of issues: notably in the field of scientific education and the shortage of scientific manpower, research into human factors in industry (a member of the General Council is Chairman of the Human Sciences Committee of the DSIR) including problems such as environmental factors in work and design, and layout of machines and places of work.

The TUC realises that in the human sciences, as with other industrial research matters, communication—the application of research and the dissemination of its results in industry—is the outstanding problem. Thus a special conference for members on "Industrial Research and Trade Unions" was convened by the TNC in July and other steps have been taken to bring home the significance of research to unions and their members.

Laboratories on the Moon

The erection of permanent living quarters and scientific laboratories on the surface of the Moon has exercised the imagination of many space scientists. One of the most common solutions so far postulated has been the use of natural caves—the inside being lined with structures from the space-ship abandoned on the surface of the Moon. Another solution has now been proposed by the Wonder Building Corporation of America, which was recently shown in model form to American officials in Washington. The plastic bubble observatory in the foreground is protected by sliding metal doors from intense ultra-violet radiation. The upper section over the structure is a protective meteoric shield, designed to ward off gnat-like rain of interplanetary meteoric dust which descends with great velocity on the barren surface of the Moon. The dome in the centre of the barrier is the traffic control tower. The whole model is built to a scale of 1 in. to 10 ft., so the moon building would be 340 ft. long, 160 ft. wide, and 65 ft. high; the shield would measure 460 ft. long, 380 ft. wide, and 83 ft. high (see illustration above).

Tea by Automation

An electronic machine which makes 640 cups of fresh tea has been introduced into this country by Elliott-Automation Ltd. It is intended for such consumers as factories and railway stations where the maintenance of an adequate staff for making large quantities of tea is a growing problem.

The customer selects his beverages by means of the dial control and receives his

tea on a tray after placing money in a slot. The tea-leaves are filter-sealed in the stainless steel teapots in which the tea is brewed. There are forty teapots, and as each pot is emptied a new one swings into position and brews a fresh supply. In slack periods an electronic timer pours off unused tea at a pre-selected time and brews it again at the required time.

The milk flows directly into the cup from the refrigerated cabinet in which it is stored. Sugar is stored in liquid form.

The machine, called "Perky", is based on an American coffee-vending machine. "Perky" is 6 ft. 9 in. high, 32 in. wide, and 23 in. deep; it weighs approximately half a ton. There is a built-in heater so that only a cold water connexion is needed for installation. No drain is required.

Another Atomic Reactor in Norway

The building of a small experimental atomic reactor is planned for the Norwegian Institute of Technology in Trondheim. This will be the fourth atomic reactor to be installed in Norway.

A Coelacanth at South Kensington

The first actual specimen of an existing coelacanth fish (*Latimeria chalumnae*) to reach this country was placed on view in the Fish Gallery of the British Museum (Natural History) this summer. It was brought over by Prof. Jacques Millot, Director of the Institut Scientifique de Madagascar, together with a plaster cast of an earlier specimen, and presented to the Director of the Museum to mark the occasion of the XVth International Congress of Zoology in London.

Coelacanth fishes have a particularly long and interesting history. They are found as fossils in rocks laid down during the Devonian period, indicating that they were in existence some 300 million years ago, and closely related fossils were deposited in many parts of the world, including Europe, throughout the succeeding 230 million years. None was known in any formation more recent than the Cretaceous, and coelacanths were thought to have been extinct for the last 70 million years.

In 1938, a large steel-blue fish with many extraordinary features was caught off the coast of East Africa and identified by Prof. J. L. B. Smith as a living member of this ancient group. It was named *Latimeria chalumnae*, and since then nearly a dozen more specimens of *Latimeria* have been collected by French fisheries in deep waters off the Comoro Islands near Madagascar. A very complete survey of the coelacanth by Dr E. Trewavas appeared in DISCOVERY, May 1958, p. 196.

The cast of *Latimeria* is exhibited in the first bay on the western side of the Central Hall, and fossil coelacanths are on view in the Fossil Fish Gallery.

Radar and Bird Migration

According to Dr David Lack, radar is likely to become an invaluable tool for ornithologists studying migration habits of birds.

Radar echoes from birds were first identified during the war at listening-posts established on the south coast of England for intercepting enemy aircraft. Experiments carried out recently have led to the detection of high-flying and mist-concealed flocks of migrant birds which would otherwise have passed unnoticed.

Dr Lack predicts that radar may prove as important in research on bird migration as the sound spectrograph has proved in the study of bird-song.

U.S. Universities to Build Observatory

Yale and Columbia Universities plan to build an observatory in Australia to provide a world centre for observations of the stars of the southern hemisphere.

Already experts have been examining possible sites. They have twice visited Broken Hill, the mining city in the far west of New South Wales. They have also visited Woomera Rocket Range and Wilmington, in northern South Australia.

It is proposed to install a 26-in. reflector telescope.

More Geothermal Power for New Zealand

In September 1958, New Zealand's first geothermal steam power plan started to operate at Wairakei, 60 miles south of Rotorua on the North Island. It is estimated that the plant will produce some 250,000 kW of power.

Meanwhile, another geothermal steam source, hotter than that discovered at Wairakei, has been found at Waiotapu, a thermal area some 18 miles south-east of Rotorua. A bore 2000 ft deep into the earth will be opened up shortly, and, according to New Zealand scientists, the new area gives promise of greater geothermal power than that which will be obtained at the Wairakei plant.

The Waiotapu bore will for the first time tap steam sources beneath layers of volcanic rock which seal the thermal heat throughout most of the area. Steam thus yielded will be drier and more suitable for power production.

Who is he?

Can anyone identify this man?

The statue, 19¾ in. high, is believed to be an iron casting from Colebrookdale Iron Foundry, but before submitting it to metallurgical examination the owner is anxious to find out if any reader of DISCOVERY knows anything of its history. The subject may be an engineer or industrialist—not necessarily British—of the mid 19th century, but all efforts to identify him have so far failed.

Who is he?

The Editor would like to hear from readers who feel they can solve the mystery of this iron man.

Tracking Rare Birds in Peru

As part of their research programme in South America, the Chicago Museum of Natural History in the United States sent an expedition to the Peruvian jungle to study bird life; their leader was Emmet R. Blake, Curator of Birds at the Museum.

The Madre de Dios region, where the expedition concentrated its activities, is a sparsely inhabited jungle rain-forest, practically unexplored by zoologists but known to be rich in bird life. A small collection of birds from the area sent to the Chicago Museum a few years ago included several species unknown to science.

Mr Blake and his companions started out from Cuzco and went in dug-out canoes down the Madre de Dios river almost to the Bolivian frontier. Most specimens for the collection were gathered on this trip down the river, but the expedition also made spot checks by chartered plane in the outlying lowland areas to see if bird life was stable throughout the territory.

Controlling the Level of the Caspian

In the last twenty-five years the level of the Caspian has begun to fall perceptibly. Compared with 1930, it has dropped by over 8 ft. and its area has shrunk by more than 19,000 square miles. In some places the water has receded 12 to 15½ miles from the shore, leaving some ports stranded in an arid desert.

Shipping and fishing conditions have also become more complicated, which is all the more important since very valuable varieties of fish are to be found in the Caspian.

The plans for re-establishing the water balance of the Caspian are based either on supplementing its water resources or on diminishing its enormous area in order to reduce evaporation.

The water resources of the Caspian are to be supplemented either by making the northern rivers—the Pechora and Vychegda—flow into it through the Kama and Volga, or by turning the flow of great Siberian rivers, the Ob and Yenisei, and directing some of their waters into the Caspian.

The creation of a Kama-Vychegda-Pechora reservoir in the north of the European part of the U.S.S.R. and the construction of a series of dams on the northern rivers would make it possible to divert from 13 to 17½ million gallons of water a year into the Caspian.

Partial control of the level of the Caspian could be achieved more quickly. Prof. Boris Apollov has suggested that a 280-mile dyke should be built to cut off the northern part of the Caspian, with an area of some 27,000 square miles, and raise the water-level in it by 6½ ft. This would make it possible to control the water reserves of the northern Caspian.

New Atomic-lighted Exit Markers

A new exit marker for use in aircraft was introduced by United States Radium Corporation, Morristown, N.J., at the 1958 Atom Fair in Chicago. The new exit marker utilises radioactive tritium gas and completely eliminates the need for electrical power and associated circuitry.

This design utilises a phosphor-tritium gas combination to obtain illumination of suitable legends. The compact construction of this high brightness marker minimises the possibility of gas leakage. In the event of rupture, the gas is rapidly dissipated into the atmosphere.

Present electrical systems for aircraft emergency exit markers have proved inadequate on several points: first, the lighting system required for signs functions only as long as the overall electrical system is operative; in the event of a crash, the entire system is useless. To maintain a separate electrical system specifically for emergency exit signs, would be unnecessarily prohibitive in cost.

Also displayed at the U.S. radium booth are samples of the company's line of sealed beta, gamma, and neutron sources, as well as other isotope-activated light sources and special markers. These include a new "lunar-white" self-luminous light source which features broadband emission and permits the use of coloured filters.

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